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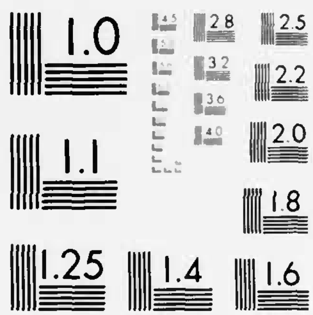
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EFFECTIVENESS MEASUREMENT IN THE
MARINE CORPS
REAL PROPERTY MAINTENANCE ACTIVITY

William T. Marsh, Captain, USMC

LSSR 8-83

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The overall objective of this thesis was to identify a measure or combination of measures of effectiveness that enable managers to evaluate RPMAs regardless of who provides the service. This objective included both defining measures of effectiveness for RPM, and developing a means of quantifying and reporting these measures. In pursuit of that objective, a literature search was conducted. Research revealed an organizational effectiveness model developed by Mahoney and Weitzel. This linear regression model, the General Business Model, was empirically developed from the perceptions of managers in 283 organizations. The model, as used, consists of four primary components, productivity, planning, reliability, and initiation. Before accounting data elements were selected as inputs to this model, it was necessary to consider the impact of the commercial activities program on the RPMA. The result was that accounting and inspection information specifications were developed to permit the proposed effectiveness measurement system to apply to contractors that may in the future maintain Marine Corps Activities. Once the contractor and in-house forces were collecting the same type of information, then the effectiveness measurement elements could be selected. The results of this process are contained in Appendix B. The effectiveness measurement system was evaluated through the use of a simulated RPMA.

LSSR 8-83

EFFECTIVENESS MEASUREMENT IN THE MARINE CORPS REAL PROPERTY MAINTENANCE ACTIVITY

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirement for

Degree of Master of Science in Engineering Management

BY

William T. Marsh
Captain, USMC

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has been accepted by the undersigned on behalf of the Faculty of the School of Systems and Logistics in partial fulfillment of the requirement for the degree of

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CHAPTER I

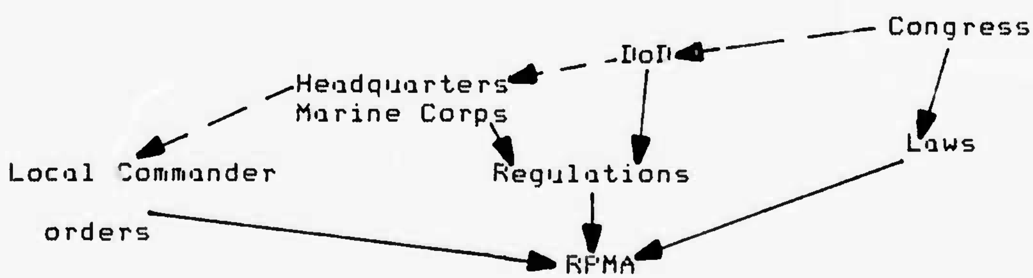
INTRODUCTION

Background

Real property maintenance is a continuous process of deficiency identification, resource estimation, resource allocation or programming, work accomplishment, and quality assessment. The organization of people at an installation involved with this process is referred to as a Real Property Maintenance Activity (RPMA) (Commandant of the Marine Corps,1980). Although the actual functions performed in this process are applicable to both civilian and military situations, historically, the term Real Property Maintenance Activity has referred to the Department of Defense activity that is responsible for maintaining the physical plant structures and facilities.

The individual responsible for managing the RPMA is, in most cases, known as the facilities officer. His responsibilities are varied, demanding, and sometimes conflicting.

The facilities officer is primarily responsible to the installation commander for maintaining the installation in accordance with the commander's desires (Ellis,etal., 1975). Additionally, the facilities officer is technically responsible to the special staff of higher headquarters for maintaining the installation in accordance with current directives (RPMA, 1968). Federal laws impose contractual and monetary limitations which further reduce the flexibility of the facilities officer (RPMA, 1968). Within these constraints each RPMA is required to perform its function in an efficient and effective manner. Figure I-1 provides a more graphic representation of the relationships described.



RPMA Guidance Sources

Figure I-1

The congress has recently begun to re-emphasize both

the improvement of productivity and the implementation of the Office of Management and Budget's (OMB) circular A-76, which established the federal policy of turning to the private sector of the economy for goods and services required by government agencies. This effort is also evidenced by a corresponding emphasis by the Department of Defense on these subjects (Melchner,1982 1983). The final impact on the RPMA is that the planning, programming and spending of the maintenance dollar is coming under significantly closer scrutiny, by Congress. Because of this DoD has developed programs to specifically implement the increase in productivity demanded by congress, as well as the Commercial Activities program established by A-76.

The DoD productivity program, established in DoD Directive 5010.31, directs "... management attention on achieving maximum defense outputs within available resource levels by systematically seeking out and exploiting opportunities for improved methods of operation." [DoD D. 5010.31, p1]. This broad description of the program further defines productivity as the "... ratio of goods or services produced (output) to resources expended (input)" [DoD D. 5010.31,p 1 encl 2]. This directive indicates that the DoD Productivity Enhancement Program is labor intensive and that the primary basis for productivity assessment will be labor measurement.

It also recognizes that labor measurement is only a subset of total factor productivity or unit cost measurement. "Where adequate cost information is available, total factor or unit cost measures may be used in addition to labor based productivity measures." [DoD D.5010.31 p2].

Any further definition of the program requires a review of DoD Instruction 5010.34, which further identifies productivity requirements through two very key definitions:

> Efficiency Measurement-
> Comparison of current performance against either a pre-established standard or actual performance of a prior period. Efficiency measurement discloses how an activity or group of individuals performs during a current period in relation to either :
> (1) a standard established for a job...; or
> (2) the level of performance achieved for the job task in a previous period. Efficiency measurement can be based upon manpower, monies, or a combination of both.
>
> Effectiveness Measurement-
> Comparison of current performance against pre-established mission objectives (goals). If the right mission objectives (goals) are established, effectiveness measurement discloses whether an activity does the right thing at the right time - - it compares what the activity or group of individuals actually accomplish in relation to their assigned mission.
> [DoD Inst. 5010.34 p10]

These two definitions are the basis for an objective evaluation of any performance. Extensions of these definitions will be provided later in this study to show the

applications to the RFMA's operations. However one additional concept must be introduced first. This concept is Cost Effectiveness. Cost effectiveness is a combination of all the previously presented concepts, and is officially defined as:

> Organizations must be both (a) effective - - accomplish the right things, in the right quantities, at the right times and (b) efficient - - accomplish the right things with the lowest possible expenditure of resources.
>
> [DoD Inst.5010.34,p1]

This idea of doing the right thing as cheaply as possible can easily be construed to mean, get something cheap, without much regard to what is being obtained. This last interpretation of cost effectiveness has led to many controversies within DoD. The most publicized controversy is the Commercial Activities Program, published by the Office of Management and Budget (OMB) in circular, A-76, in 1966. This circular re-emphasized the federal policy of turning to the private sector of the economy for goods and services required by governmental agencies. These services range from refuse disposal to total Base Operation Services (BOS).

The circular was designed to provide the most efficient services to the government whether procured through con-

tract or in-house. It was intended to be a management tool to "... tighten up the organization" or have it converted to a contractor [Payne 1982.,p.13].

This goal is an admirable one, yet it has had a very significant negative impact upon federal employees. Many federal employees view A-76 as a threat to their job security (Rogers, 1981). This is a perception that has proven to be more of a fact than a perception. Once a function has been converted to contract, the federal employees formerly performing this function are displaced under civil service reduction-in- force regulations. Those personnel positions that are reduced by the contractual action are either converted to other functions or simply lost altogether. As yet there are no guidelines that provide for regaining these positions in future commercial activity reviews.

On the other hand, reviews of commercial activities (C.A.s) that have been contracted out since 1977 have shown that excessive cost increases have not occurred without proportional increases in the initial scopes of work or from poor statements of work (Horan, 1981; Jones, 1980).

Employees fears are also validated by the fact that the government work force has been reduced by 120,000 employees between 1970 and 1980 (Compt Gen Rpt.,1981). This reduction

may have been caused in part by some government agencies having gone further in their implementation of A-76 than was originally intended. A recent General Accounting Office report has indicated that some functions have been contracted out that are not included within the provisions of A-76 (Compt Gen Rpt,1981). This has meant an additional loss of civil service positions.

Military commanders have two concerns with A-76. The first is that contracting out reduces their flexibility to react to special situations, and second that contracting out reduces the service's ability to maintain military proficiency in these functional skills in order to support combat requirements (Rogers, 1981; Lawter, 1981). The loss of flexibility is supported by the Defense Audit Agency's report which indicated that initial costs were increased due to inadequacies in the initial performance work statements (Melchner, 1983). These inadequacies were noted after the contract was awarded.

The second concern is that the reduction of CONUS positions for military personnel will reduce the training available for certain specialties. This situation was found to be very true for the Navy and Air Force (Lawter, 1981). Both of these services utilize their military personnel to

conduct commercial or industrial type activities in peace time in order to provide sufficient training for their respective combat roles. Paragraph 8b(1)(c) of A-76, however states that the government may operate a commercial or industrial type activity by military personnel when "the activity is needed to provide appropriate work assignments for career progression or a rotation base for overseas assignments" (A-76,1979,p.7).

The Department of Defense has implemented the A-76 commercial activities program with DOD directive 4100.33 and has provided cost comparison guidance with DOD instruction 4100.33H. Both of these documents were derived from the A-76 document and from OMB's cost comparison hand book respectively. These two manuals are the basis for each service's implementing instructions.

The determination of how such work will be performed is based on a study conducted in accordance with the Cost Comparison Handbook published by OMB. The guidance contained in DoD Instruction 4100.33 and 4100.33H, states that the in-house manager must prepare a bid to do the work that has been determined to be contractable. The bid is then submitted to the contracting officials to be considered along with prospective contractor bids. The lowest bidder wins the

contract, even if it is the government activity.

The commercial activities program has largely been used for separate functions within the maintenance and operations of various government agencies. These functions include grounds maintenance, refuse collection and shuttle bus service. The trend however, is a preference for total base operations contracts. The operation and maintenance of a total base function is a large and complex contract. There are, however large total base operations service contracts that have proven successful. For example, the Trident Submarine Base in Bangor, Washington, has been used successfully by the Navy, and the USAF Eastern Test Range (Cape Kennedy) service contract has a 34 year history of success (Rogers, 1981).

The maintenance of real property has been defined by A-76 as a commercial activity, subject to contracting out. Within the Marine Corps, the total maintenance function has not been contracted out. However, two Marine Corps activities are considering this option. As contracts of this nature have succeeded in other services, it is expected that they will succeed at Marine Corps Activities as well(Rogers,1981). Before this work can be contracted out,however, the A-76 process requires that both the con-

tractor and the government in-house forces prepare bids on the work specified.

Problem Statement

Neither the present Marine Corps RPMA evaluation system, nor the Marine Corps service contract management staff are prepared to evaluate the effectiveness of the maintenance service contractor. Additionally, the Facilities Maintenance Management Reporting system does not capture the information required to conduct Commercial Activity reviews of military efforts on commercial activities as required by A-76(OMB,1979).

The implied tasks that accompany real property maintenance include work generation, work control, work accomplishment, and appraisal. In order to ensure that the facilities are being effectively maintained, measures of effectiveness for these four areas must be identified for both contractor and in-house forces, as well as provisions being included in both the Performance Statement of Work (PSOW), and the Facilities Maintenance Management Reporting (FMMR) system to collect and transmit this information to the service contract manager or the maintenance officer.

Summary level indicators of this information must then be forwarded to Headquarters Marine Corps for evaluation(CMC,1980).

Justification for Study

Congressional interest in the Productivity and Commercial Activities of DoD has focused on the effective management of DoD Real Property Maintenance Activities. The congressional objective is to provide the government with the most cost effective organizations, whether in-house or contracted out. (Payne p 13).

DoD has established management guidance for the services. That guidance, however essentially directs each component to establish its' own Productivity program.

> This will require the establishment and use of summary level indicators which represents true measures of the prime measures of each functional area and the accumulation of output and input data for each indicator. Normally a separate indicator should be established for each major product produced or service rendered in the functional area.
> [DoD Inst 5010.34,p 3]

The need for summary level indicators has also been

identified in both Army studies reviewed. (Knight 1978, RPMA 1968). These summary level indicators, or indices, can be used by managers to evaluate the performance of the individual RPMAs.

The Headquarters Marine Corps Real Property Maintenance section is responsible for managing the RPM program. In recent interviews with key personnel of this section, the need for revision of their current effectiveness measures was identified (Lee, 1983).

Research Objective

The overall objective of this thesis is to identify a measure or combination of measures of effectiveness that enable managers to evaluate RPMAs regardless of who provides the service. This objective includes both defining measures of effectiveness for RPM, and developing a means of quantifying and reporting these measures.

Research Questions

1. How can an effectiveness measurement system be constructed for Marine Corps Real Property Maintenance Activities?

2. What measures of effectiveness should be extracted from present information systems?

3. How will the measurement system identify problem areas or efficiency and effectiveness shortfalls?

Assumptions

1. For purposes of this study, only current DOD and Marine Corps directives will be utilized.

2. Data requirements for Congressional directives will not be discussed in detail, however they will be mentioned as appropriate.

3. The contract manager will be a member of the Facilities Maintenance Officer's staff, as specified in CMC message 080017 z Jan 1982.

4. By achieving a 100% level facilities inspection program, at least 95% of the total deficiencies will be identified.

5. The service discussed will be for maintenance only. Major repairs will be accomplished by separate construction contract.

6. Automated cost accounting procedures at each activity, if not completely accurate, can be made so with sufficient command attention.

7. Programmed work estimates for in-house forces will be developed from Engineering Performance Standards.

Scope

This study will concern only the U.S. Marine Corps Real Property Maintenance Management system. It will attempt to identify measures of effectiveness to be used by Marine Corps RPM managers at intermediate and strategic levels of management. These measures must meet the following requirements;

1. Optimally measure overall effectiveness.
2. Comply with Commercial Activity cost comparison specifications.
3. Comply with current DoD and statutory regulations.
4. Be compatible with current accounting systems.

Plan of Report

This initial chapter provides a background for the reader as to the character of the Real Property Maintenance Activity. Chapter II provides the necessary literature review on methods of effectiveness measurement. Chapter III develops the model and the analysis of the RPM process identifying the necessary effectiveness measures, to be used in evaluating the RPMA. Chapter IV develops the relationships of the proposed model components, and develops the actual simulation program. Chapter V describes the experimentation

process as conducted. Chapter VI presents the conclusions of both the research and the experimentation.

CHAPTER II

LITERATURE REVIEW

Current Practices of Effectiveness Evaluation

Effectiveness in the Real Property Maintenance Activity has been the subject of two major studies over the past fifteen years, both conducted by the Army's Office of Civil Engineering. One was done under contract by a civilian firm (Knight, 1978), and the other was an in-house study performed by a Real Property Maintenance Study group (RPMA,1968).

From the earlier study, a need was identified for an index or maintenance standard by which all maintenance installations could be evaluated (RPMA, 1968). Ten years later, no consistent set of performance measures had been developed or applied (Knight, 1978). By studying maintenance activities at civilian firms, universities, and municipal governments, Knight developed a large base from which measures and procedures could be compared.

By comparing civilian industry maintenance activities to the Army's RPMA, Knight determined that civilian industry was more effective because:

1. Industry is highly cost conscious and uses relatively simple financial controls to monitor performance. This is interpreted as a measure of productivity considering efficiency as a subset of productivity.
2. Industry has the flexibility to adjust the personnel structure to meet changing demands.
3. Industry was conscious of how the facilities were utilized and attempted to maximize their use. This is interpreted to mean that industry was successful in planning their operation.
4. Industry consolidated engineering expertise above the plant level in order to provide supervisory control and coordination among plants. This is interpreted as providing more reliable and consistent design work.
5. Industry commonly provided more autonomy at the plant manager's level than the RPMA manager was allowed. This is interpreted as a measure of initiative, in that the plant manager was freer to test management innovations.

(Knight, 1978)

These measures identified by the Knight study are significant in that they address both costs and the more abstract aspects of initiative and flexibility. These measures will be evaluated more closely in the following sections.

Studies of Naval Real Property Management systems, while not as extensive as those of the Army, have identified several objectives of these systems. These include

1. Increasing productivity of the work force.
2. Controlling and coordinating the maintenance workload and workforce.
3. Providing a means of directing the efforts of the workforce to some departmental goals.
4. Reducing costs in conducting maintenance.
5. Allowing for selectivity of flexibility between alternatives.

(Ellis, et al., 1975)

A comparison between the Navy RPM objectives and the measures of effectiveness identified in the Knight study reveal several significant parallels. These include concentration on control, productivity, planning and flexibility. The actual significance of these similarities will be

developed later in this chapter.

Research did not reveal any major studies of RPMA with respect to the Air Force or Marine Corps. Some studies were found that addressed portions or components of the RPMA's operations. However, none of these studies was sufficiently comprehensive to permit an overall evaluation of the organization. The Marine Corps does not specifically identify organizational objectives in its Real Property Maintenance manuals. It does however, prescribe methods, procedures and forms for conducting the real property maintenance operation. (CMC, 1980). These methods are in accordance with DoD objectives and guidelines.

Although the U.S. Coast Guard is not a part of DoD and therefore is not required to conform to DoD programs, they have developed a system of facility evaluation that addresses both the physical condition and the functional adequacy of the facility for its mission. This system is designated the Facilities Adequacy Scoring Technique (FAST). The FAST system is an inspection procedure that produces a numerical index for the physical condition and the functional adequacy of the facility. The idea of indexing the condition of a facility is not new. The Army has developed a condition code for it's Integrated Facilities System (IFS)

(Barry,1969). The FAST system is a significant improvement over the IFS system, as it provides a measure of the adequacy of the facility to support it's intended purpose. A particularly significant impact of this system is that decisions on resource allocation are based on the results of the FAST scores, as well as "... evaluating the success of the Civil Engineering maintenance effort." (Lucas, 1982). The FAST system however, does not directly evaluate the maintenance process. This is crucial because without analyzing the process there is no way to measure efficiency or effectiveness.

Regardless of how system and objectives are established, to an RPMA the acid test is the evaluation performed by either higher headquarters, or by independent audit agencies. The independent agencies referred to here are the General Accounting Office, DoD Audit Agency, and the audit agencies of the various services.

Four Army Audit Agency reports that evaluated four different RPMA's were reviewed. All four of these audits focused on the quantitative and procedural aspects of the respective organizations. Deficiencies were consistently identified in the following areas;

1. Planning work
2. Scheduling or controlling work(a measure of reliability as well as supervisory control)
3. Efficiency of the work force
4. Assessing quality
5. Sampling to determine areas that need improvement

(USAA Ft.Bragg, Ft.Benning, Ft.Rucker, 1978; Ft.Campbell, 1980)

The fact that these deficiencies identified by the agencies are similar to the problem areas identified in the Knight study is significant. It indicates that, at least on the quantitative measures the services are adequately addressing the same type of objectives that civilian industry is. Notably lacking in these audit reports was any evaluation of either flexibility or initiative.

Similar results were obtained from GAO reports and DoD Audits of RPMAs. They consistently identify deficiencies in areas of work identification, work planning, work accomplishment, and work appraisal (Compt Gen rpt 1979). Recent GAO and DoD studies have specifically concentrated on the Commercial Activities program (Melchner 1983). The problems identified here are those of effective service contract

management. This is a growing problem in Marine Corps Real Property Activities, and will be developed further in the next chapter.

It is apparent that there are a number of measures of effectiveness in use for evaluating the RPMA. Even from the DoD level, most of these measures deal in resource costs. The evaluation of a DoD RPMA only in terms of cost, can detract from the primary mission of DoD, which is the nation's defense. Though costs should be considered in measuring effectiveness, there are additional factors to be considered. (Arnold and Fink 1974).

Effectiveness Theories

The concept of organizational effectiveness has been the subject of many studies in the past two decades. A 1977 review of some seventeen studies on organizational effectiveness concluded that effectiveness should be examined from the aspects of goal optimization, a systems perspective, and human behavior within an organization.(Steers 1977). The idea of organizational goal attainment was basic to many of the studies on organizational effectiveness reviewed by Steers.

> The major advantage of the goal approach in evaluating effectiveness is that organizational success is measured against organizational intentions instead of an investigator's value judgements(that is what the organization "should" be doing). Because different organizations pursue widely divergent goals, it is only logical to recognize this uniqueness in objective evaluation attempts.[Steers,1977,p5]

Another advantage to the goal approach is that it can be easily quantifiable with careful selection of goal parameters. This particular aspect of organizational effectiveness can be adapted to the number oriented Real Property Maintenance Activity. Steers emphasizes that goals should be collectively optimized rather than individually maximized. As an example, consider the space program's goal of putting a man on the moon. It effectively achieved this goal; however, the goal of efficiency was not maximized (Steers, 1977). As an extension of the same program, consider the space shuttle program. By developing a reusable space craft, the emphasis is now more on efficiency. This concept of optimization would appear to work best in an organization with both multiple goals and multiple constraints, such as the space program.

The second aspect suggested for understanding

organizational effectiveness is a systems perspective. The systems perspective views goals in a dynamic framework, one where goals are constantly changing over time (Steers,1977). The RPMA is an organization that is fluid in nature. It is not the change in quantitative goals that make them fluid, as these goals are relatively constant. It is the organization itself that becomes dynamic with each change of the maintenance officer, key maintenance personnel, or the installation commanders. Each change in personalities causes a corresponding change in the emphasis of the goal optimization process. This is primarily due to the different leadership styles and personal biases of each individual that assumes the responsible position.

The remaining aspect of organizational effectiveness is human behavior in organizational settings (Steers, 1977). The RPMA is comprised of both civil service and military personnel. The ratio of military to civilian varies between the services. Their individual contributions to goal attainment depends on many variables, which are the same for all RPMA organizations. Variables such as relative competence, experience, expertise, and knowledge of procedures are some of the variables that fall into this category. These types of variables were not addressed by any of the studies or audits reviewed on actual RPMAs. Therefore they

will not be addressed here.

Steers also evaluated the seventeen studies in terms of criteria or dimensions that accounted for much of the variation in the effectiveness of the diverse organizations studied. An important consideration in developing effectiveness criteria is to "... ensure that the criteria are consistent with the goals and purposes of a particular organization (Steers,1976,p.53)." Measuring effectiveness, even in relation to the organizational goals requires some form of measurable criteria. In Steers' review of the effectiveness studies, a small degree of commonality was observed. More notably, the criteria of adaptability or flexibility was mentioned in over half of the seventeen studies (Steers, 1977).

The concept of adaptability or flexibility refers to the ability of managers to adapt their organizations to changes in the working environment (Steers, 1977). As previously stated, the influx of personnel in the RPMA creates a constantly changing work situation. Additionally, as the management of RPM at the headquarters level becomes more sophisticated, the requirements placed on the individual installations for reporting and managing will increase (Commandant of the Marine Corps,1980). The individual facili-

ties officer must, if he is to be successful, be able to quickly change his organization to coincide with new directives and guidelines.

The second most prominent criteria noted by Steers was productivity. Productivity is referred to here as a summation of output for a given period. This is not to be confused with efficiency, which was also mentioned in these studies. Efficiency is a ratio, or at least a comparison, of outputs to inputs (Steers,1977). Productivity deals in the maximum use of time while efficiency deals in the maximum use of all types of resources (Steers,1977). These two similar concepts can easily be quantified in the management of real property. The productive use of time and the efficient use of materials and equipment are important considerations when evaluating an RPMA.

When dealing with effectiveness of an RPMA, one is affecting or can affect many RPMA employees and military tenants of facilities. Because an effectiveness rating will result in a reallocation of resources or possibly manpower reductions, it is important that the criterion for measurement be as comprehensive as possible. In an effort to assure the validity of criterion to be used, Cameron's six critical questions in evaluating organizational effective-

ness will be employed. These questions are:

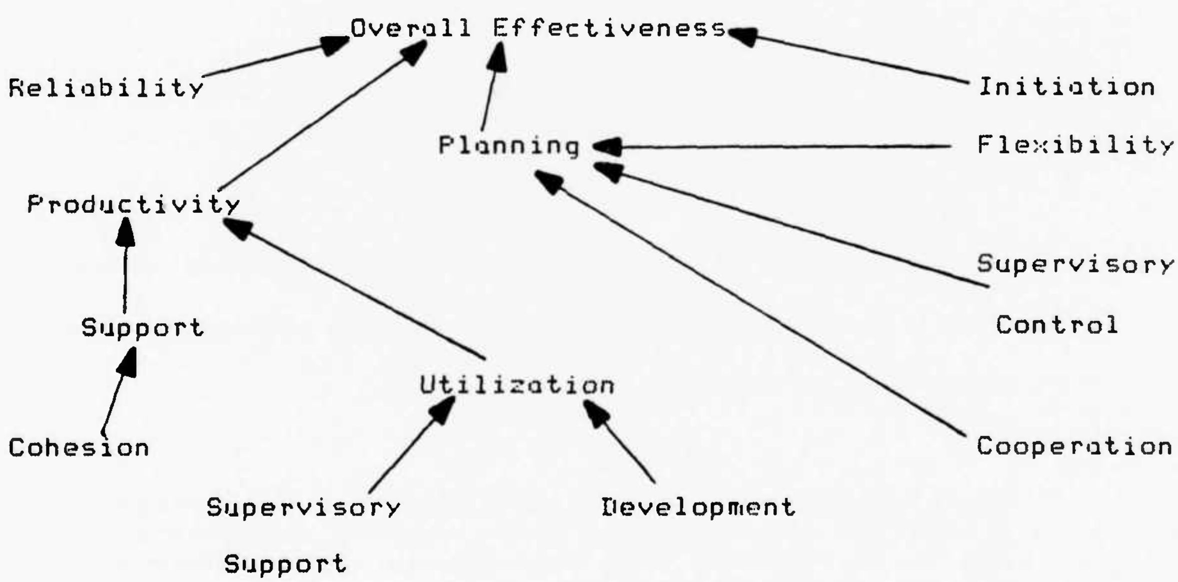
1. What is the domain of activity being focused on?
2. Whose perspective or point of view will be used?
3. What level of analysis is being used?
4. What time frame is being employed?
5. What type of data are to be used?
6. What referent is being employed?

[Cameron,1980,p. 72]

Employing the above six questions in the criterion selection process should assure that valid and reliable measures will be obtained. However, the framework of the overall effectiveness evaluation should be an optimization process in view of the many conflicting constraints placed on the RPMA management personnel.

In order to evaluate an organization and to predict and direct its functions, a full understanding of the relationships of its component parts to the whole is required. One method of understanding these parts is to construct a model. Many models of organizational effectiveness have been constructed and tested. Each model attempted to evaluate organizational effectiveness, some for a limited community, others on a more universal basis. Mr. Thomas A. Mahoney and William Weitzel have empirically developed a model that

could do well in evaluating organizational effectiveness in the RPMA. This model, called the general business model, was capable of accounting for some 65 percent of the variance in judgements of ultimate effectiveness (Mahoney & Weitzel,1969). This model was empirically constructed from a survey conducted in 283 organizations. The model is best summarized in the following figure:



General Business Model

Figure II-1

The primary criteria for evaluation under this model

are listed in order of their importance : reliability, productivity, planning, and initiation (Mahoney & Weitzel,1969). It is interesting to note that these four characteristics are part of the requirements for managing a Real Property Maintenance Activity (Commandant,1980). It would seem that this model would serve well as a normative basis for a new Marine Corps effectiveness measurement system.

Summary

All models and studies reviewed in preparation of this topic had a common theme, regardless of the approach taken. This consensus is best expressed as :

> The practicing manager must accordingly demonstrate a capacity to understand these various approaches and to derive from them such models whose concepts are most applicable to his or her own unique situation, [Steers,1977,p.50].

There are numerous methods of measuring organizational effectiveness. The Department of Defense requires the use of summary level indicators for effectiveness measurement. It also requires each service to develop its own indicators

based on cost and labor measurements.

CHAPTER III

METHODOLOGY

Overview

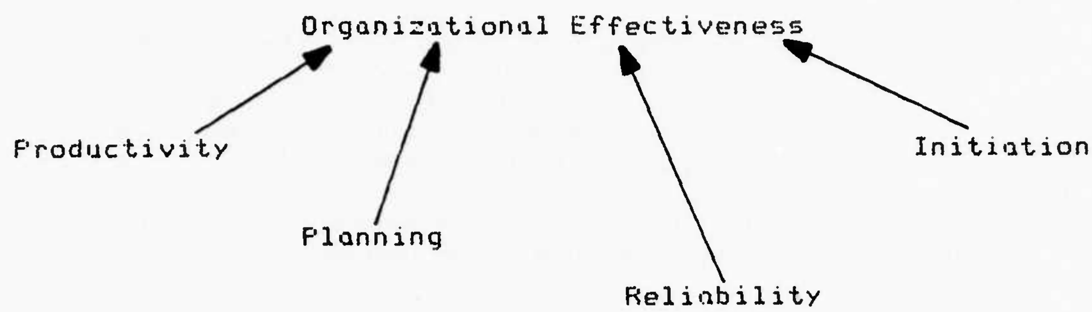
The objective of this thesis is to identify a measure or combination of measures of effectiveness that enable managers of Real Property Maintenance Activities to comprehensively evaluate the performance of their activities. The measures selected must be compatible with current DoD and Marine Corps Real Property Management programs. Additionally the system will be designed for use by headquarters level managers. Information should be transmitted in the form of a timely report submitted by each activity. The report format must be applicable to those activities maintained by contractors as well as those by in-house forces.

A decision support system will be utilized to identify the essential elements to be used as measures of RPMA effectiveness. The first step will be the description of the

maintenance process. This will be accomplished through the use of IDEF diagrams, which will be explained later in this chapter. The identified elements will serve as inputs to General Business Model which will produce an effectiveness rating. A simulation of actual RPMAs will be used to generate data for the rating system. The data generated by the simulations represents data currently available through USMC accounting systems. The simulations represent ongoing RPMAs and produce output in the format of a full fiscal year of reports.

Selection of effectiveness measures can be made only after the contracted maintenance process is required to accumulate data that is similar to that presently collected by in-house forces. The data required will be developed in the next chapter.

The effectiveness measurement report will be constructed through the use of a conceptual model. The conceptual model is a component or factor representation of a concept. In this case, the concept will be organizational effectiveness, and its components, the factors used to describe it. The model selected is shown below;



Modified General Business Model

Figure III-1

This model is the General Business Model, developed by Mahoney and Weitzel, and was introduced in the previous chapter. This model used four primary dimensions of effectiveness to evaluate the overall effectiveness of a business organization. These four dimensions, with their subordinate factors, were successful in explaining the responses of 56% of the organizations surveyed. This is significantly better than any of the other models reviewed. Therefore, this model was selected to evaluate the overall effectiveness of Marine Corps RFMAs. The dimensions of the model are defined as;

Reliability - Consistently meeting objectives

Productivity - Efficient performance and resource utilization

Planning - Operations are planned and scheduled to avoid lost time and crisis management. This includes the flexibility to incorporate environmental changes in the planning of operations.

Initiation - The ability to take steps to improve work methods and operations.

The model will be limited to these four primary dimensions because "The secondary dimensions in the model tend to be descriptive of organizational behavior rather than output or performance; this, then might be viewed as criteria of organizational capability for future output performance."[Mahoney and Weitzel, 1969, p. 360].

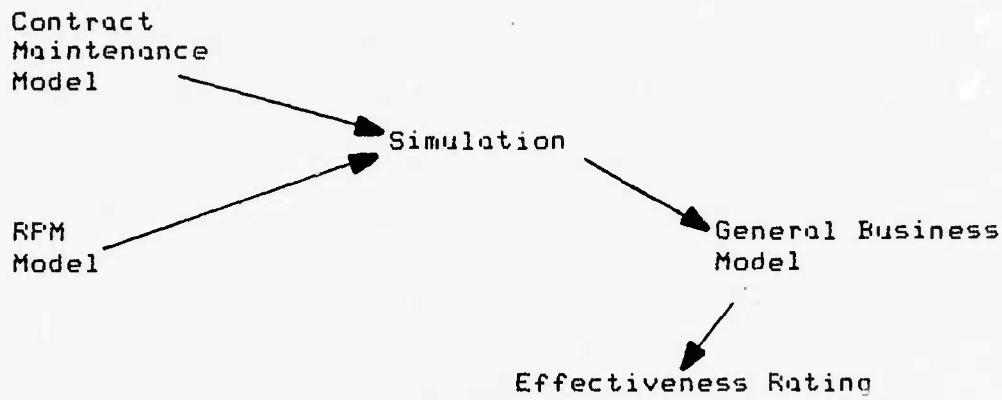
Mahoney's analysis of the four primary dimensions with their subordinate factors concluded that the dimensions of productivity and planning were most significant in explaining the evaluations of overall effectiveness (Mahoney & Weitzel, 1967). The selection of these two factors as measures of effectiveness is consistent with the productivity and planning guidance provided the various services by DoD. As previously stated, DoD and congress have been concerned with proper planning and productivity in the management of Real Property. A comparison of DoD definitions presented earlier and Mahoney's definitions shows a high degree of correlation. This makes the analysis of the dimension of

productivity much easier as the DoD cost accounting system already has provisions for data collection. The analysis of the planning dimension is also facilitated as the Marine Corps has specific guidelines for planning documents (CMC 1980).

Simulation Modeling

> Simulation is the process of designing a model of a real system and conducting experiments with this model for the purpose of either understanding the behavior of a system or evaluating various strategies (within the limits imposed by a criterion or set of criteria) for the operation of the system.[Shannon, 1975,p.2]

The system to be simulated for this study is the Real Property Maintenance Activity. The model represents the work control and the work accomplishment processes of the activity. The function of the model is to accomplish work identified by an Annual Work Program, within the constraints of manpower and funding. Performance data on these processes will be collected and converted into the proposed effectiveness evaluation system. The process to be followed is illustrated in Figure III-2.



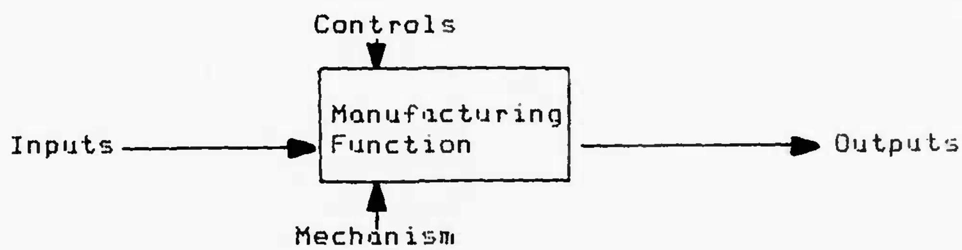
Thesis Methodology
Figure III-2

<u>Modeling Tools</u>

The selection of actual elements or factors to be included in the final model can only be accomplished after an analysis of the RPM process. This analysis will be accomplished through the use of a process model recently developed for the Air Force's Integrated Computer Aided Manufacturing (ICAM) program. This modeling system is known as IDEFO (Softech, 1981).

> IDEFO is used to produce a function model which is a structured representation of the functions of a manufacturing system or environment, and of the information and objects which interrelate those functions.[Softech, 1981, p.3-1]

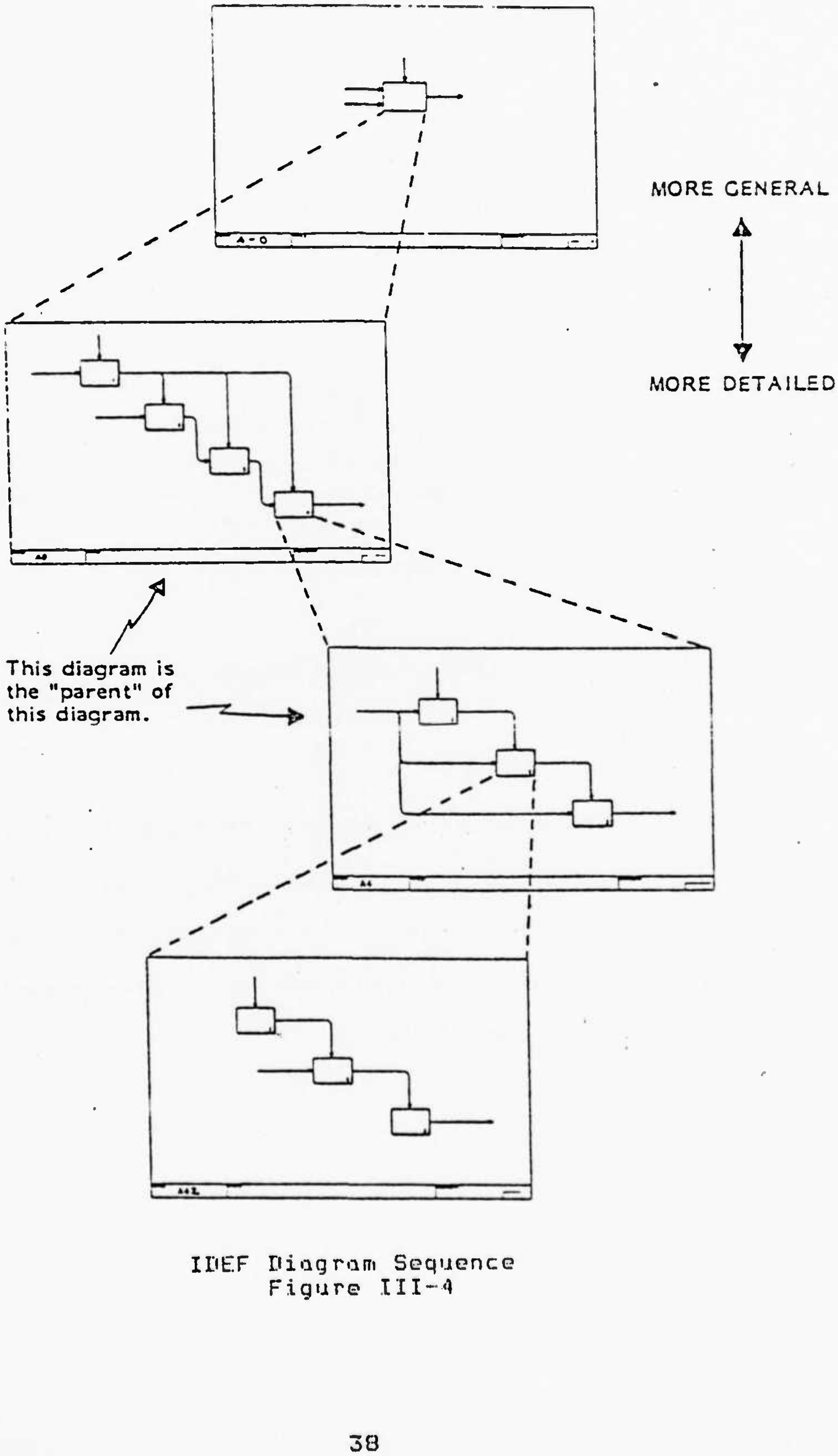
The IDEF model uses a series of boxes and arrows to represent the various functions and activities. An example is shown in Figure III-3.



IDEF Process Model

Figure III-3

The manufacturing process is further divided into the sub-functions that comprise it. These sub-functions are represented in additional boxes that present a more detailed picture of the manufacturing process. A graphic example of this is depicted in Figure III-4.



IDEF Diagram Sequence
Figure III-4

For purposes of this study, the maintenance process will be represented without reguard to organizational structure, but with respect to the processes required. Once the RPM process has been modeled, the process as it applies to the contracted maintenance will be addressed through the use of a decision support system construction process.

Decision Support Systems

The decision support system process will be used in this thesis to perform two functions. First it will be used to identify information that will be required from the contract maintenance process to develop planning, programming and productivity data. Second it will be used to select effectiveness elements from the RPM process to serve as inputs to the effectiveness measurement system.

Computer technology has advanced to the point that data (information) can be collected, and otherwise processed at amazing rates and quantities. The manager of today has more information available to evaluate than ever before. So much so that there may be too much information for the manager to effectively use.(Hussain 1981). A manager is normally responsible for making decisions and generally conducting

business. This is no less true for the Real Property Maintenance Manager. In order for the headquarters level manager to manage his activities it is essential that he have sufficient information, but not too much. He must determine exactly what information is needed, why it is needed and how often it is needed.(Hussain 1981,p.11) This is, in reality, the pre-design phase of constructing a Decision Support System.

Decision Support Systems (DSS) are an outgrowth of Management Information Systems(MIS), and are intended to be management tools. They are tools aimed at improving the effectiveness of a manager with the design of the system under the control of the manager.(Keen 1978,p.2). These systems have been implemented in several industries, with a great deal of success. (Keen 1978,p.15).

The development of the DSS occurs in three phases. The first phase requires that key decisions be identified. This phase will be referred to as the pre-design phase. It will require the construction of both descriptive and normative models of the decision making process. It will also generally define objectives for support effort, as well as perspectives and key interests.(Keen 1978, p.175). In effect it will provide design specifications.

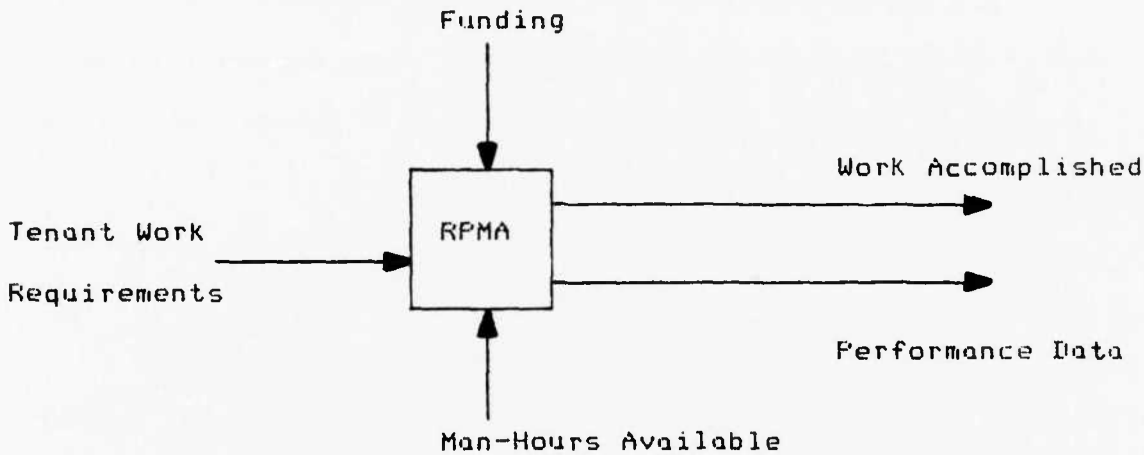
The second phase or design phase, requires the refinement of the objectives and eventually the construction of the actual system. The design phase will answer the following questions:

1. What do we want the DSS to accomplish?
2. How will we recognize when the system is complete-that is, when it has met its design objectives?
3. What are the priorities and or sequence of stages planned to meet the design aims? [Keen, 1978, p.180]

Once these questions are answered, then the final phase, the implementation phase, can begin. In this study the implementation phase will be a recommended sequence of implementation steps.

System Definition

The Real Property Maintenance Activity can be characterized using the IDEF configuration shown in Figure III-5



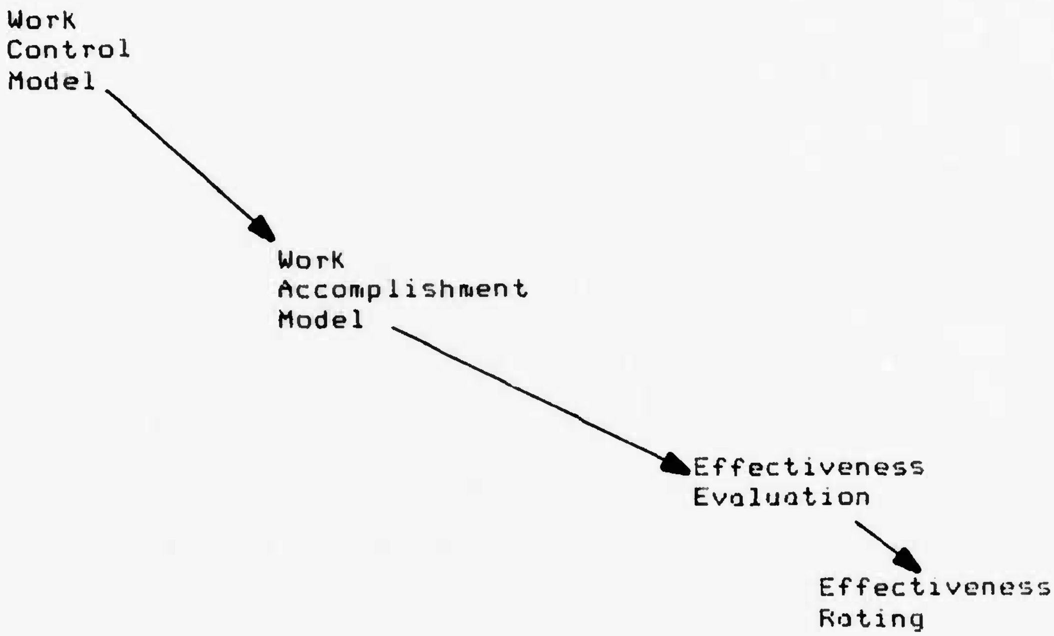
Real Property Maintenance Process

Figure III-5

The individual maintenance processes conducted by the RPMA will be further analyzed in the following chapter. The process basically requires that deficiencies be identified, corrective action be estimated, programmed, and accomplished, and finally the work should be appraised for quality and completeness. Performance data from the areas of work generation, and work accomplishment will be collected and processed in to an effectiveness evaluation.

Model Formulation

This simulation is intended to capture performance data involved in the RPMA operation. These performance data are the result of the sequential execution of an Annual Work Program (a listing of work programmed to be accomplished during the fiscal year), requiring the consumption of two primary resources, man-hours and dollars. A graphic representation of the model is illustrated in Figure III-6.

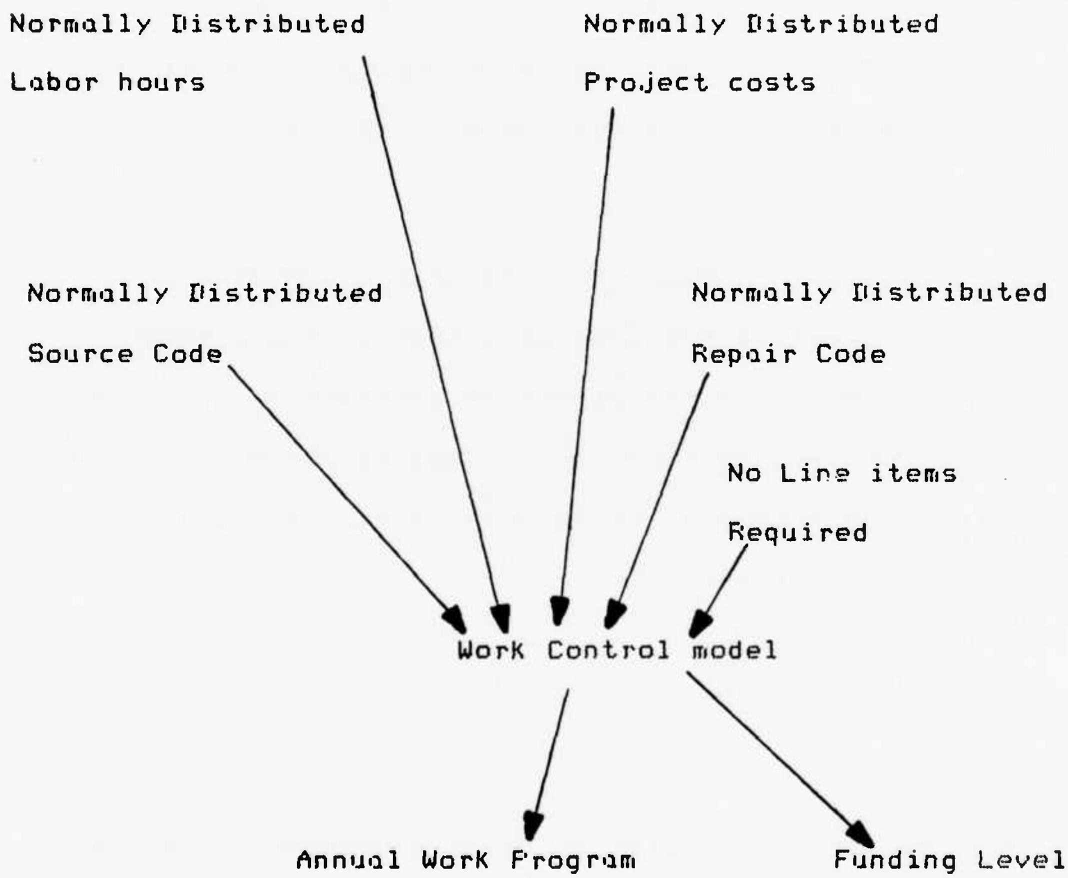


RPMA Simulation Model

Figure III-6

Work Control Simulation Model

The work control model is illustrated in figure III-7.



Work Control Simulation Model

Figure III-7

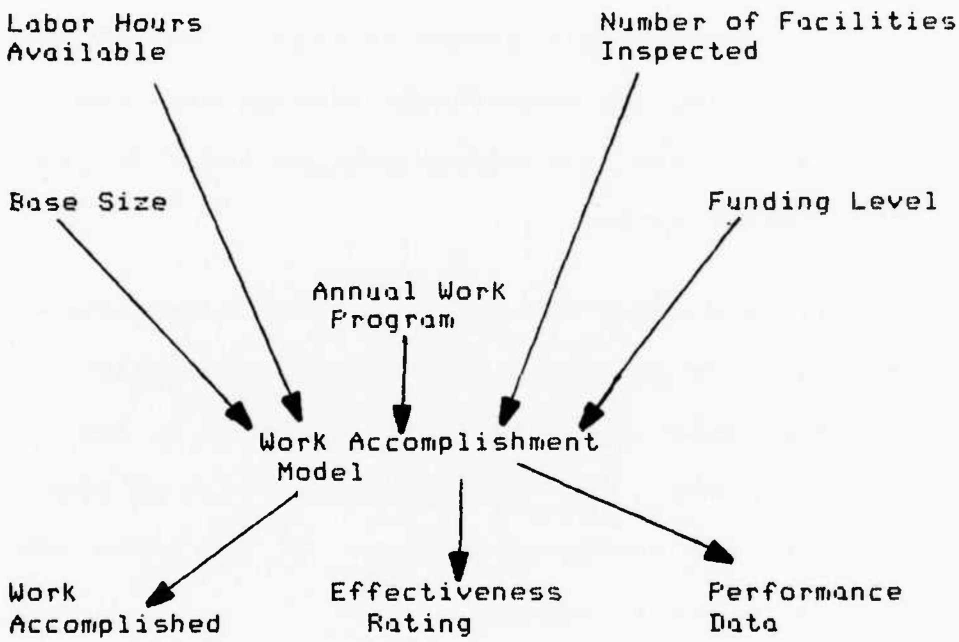
The labor and dollar components represent the estimated resources required to correct the deficiency identified by the line item. The work source code component identifies the source of the work requirement. This will be from either the Long Range Maintenance Plan, tenant requests, or other unprogrammed sources. These unprogrammed sources represent emergency requirements or work that was not anticipated.

The repair code component represents a programming decision to accomplish the work by either in-house forces or by contractor(small service or repair contracts). The percentage for contract or in-house accomplishment will vary with the size of the base, as does the number of line items required to be generated.

Work Accomplishment Simulation Model

The Work Control Simulation Model generates an annual work program that represents a full fiscal year's worth of programmed work. The Work Accomplishment Simulation Model executes the annual work program and collects performance data for effectiveness report preparation. For ease of programming the effectiveness evaluation system was included in

the work accomplishment simulation. The Work Accomplishment Simulation Model is illustrated in Figure III-8.



Work Accomplishment Simulation Model
Figure III-8

The labor and funding components of the model are two of the variables that will be manipulated, and will be determined from the Annual Work Program component. The base size component is the number of facilities that the RPMA is required to maintain. The facilities inspected per quarter represents the number of facilities that the activities' inspection section has actually inspected during the quarter.

Data Requirements

The data elements described here represent the input data for the Real Property Maintenance Process. These data will be processed by the two subordinate simulations, the Work Control model and the Work Accomplishment model to produce the effectiveness rating.

As previously described the data used in the construction the RPMA model are generated from either a normally distributed random number generator or established by the author for test purposes. Each data structure will be discussed in detail in the following chapter. Listed below are the data elements and their sources.

Table III-1
Work Control Model Variables

Data Element	Source
Labor Hours	Normally Distributed Random Number
Project Cost	Normally Distributed Random Number
Repair Code	Normally Distributed Random Number With selection parameters
Source Code	Normally Distributed Random Number With selection parameters
No line Items rqd	Established in relation to base size

Table III-2
Work Accomplishment Model Variables

Data Element	Source
Annual Work Program	Work Control Model
Base Size	Established by the Author
No Facilities inspected per quarter	Normally Distributed Random Number
Labor Hours Available	A percentage of the hours generated for the Annual Work Program
Funding Level	A percentage of the costs generated for the Annual Work Program

Experimental Design

Several different experiments were conducted with the RFMA model. Each experiment was conducted for three different base sizes, in order to demonstrate the applicability of the effectiveness measurement system for all Marine Corps Bases. Parameters tested to determine the sensitivity of the model were labor hours available, funding level, levels of programming(the source code) and the level of inspection. Chapter V contains descriptions of the simulation experiments and their corresponding scenario's.

Summary

The development of an Effectiveness measurement system

for Real Property Maintenance activities will be accomplished through the use of a conceptual model of overall effectiveness. This conceptual model includes four primary dimensions of effectiveness. These dimensions are productivity, planning, reliability, and initiation.

The selection of elements for the proposed effectiveness rating system will be accomplished only after specifications were developed to enable contracted maintenance activities to collect information similar to that currently collected by in-house forces. The actual selection process was accomplished through the use of a decision support system construction process.

CHAPTER IV

THE MODEL AND ITS ELEMENTS

Overview

The effectiveness rating system will be based on Mahoney's General Business Model. This conceptual model will then be applied to the maintenance process, as developed for the contracted maintenance specifications construction.

As previously described, the conceptual model includes the primary components of reliability, productivity, planning, and initiation. Mahoney's research identified a definite importance level for each of the four primary effectiveness factors. These significance factors will be applied to the proposed rating system. The factors will approximate the weights established by Mahoney's linear regression model. The effectiveness measurement elements will be weighted according to the following equation;

$$
\begin{aligned}
\text{Effectiveness} = \; & .45 \times \text{Productivity value} \\
+ \; & .25 \times \text{Planning value} \\
+ \; & .17 \times \text{Reliability value} \\
+ \; & .13 \times \text{Initiation value}
\end{aligned}
$$

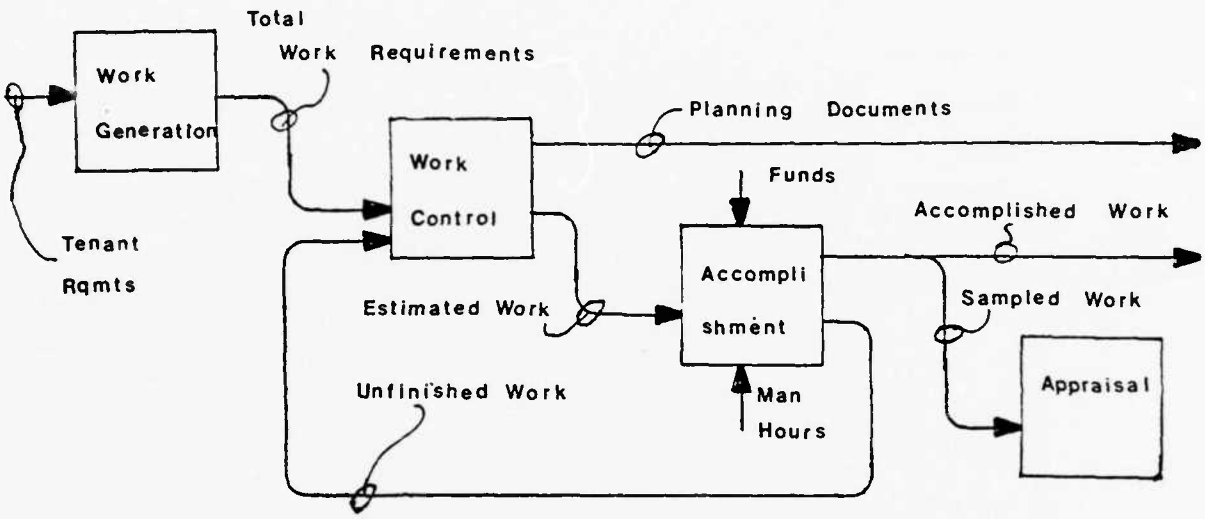
The final result of this thesis, an effectiveness measuring system, will be used to compare various Marine Corps RPMAs, and accordingly allocate resources. The selection of specific elements for the effectiveness measurement model and the data collection specifications for contracted maintenance will be performed through the use of a decision support system construction process.

Now that the effectiveness rating system has been established, it is necessary to select elements of information, presently available, to provide data for the rating system. This will be accomplished through an analysis of the RPMA process model.

RPMA Process Model Description

As previously stated the process of DOD Real Property Maintenance is a continuous one. The essential elements of the process are work generation, work control, scheduled

accomplishment, and work appraisal. Their relationship is shown in the following model:

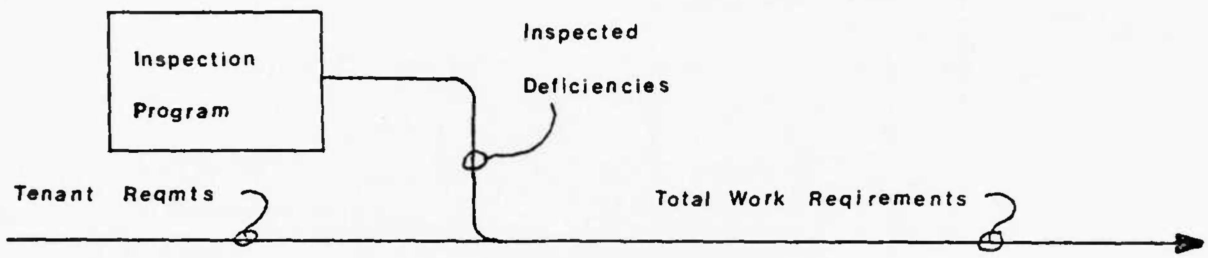


RPMA Process Model

Figure IV-1

In this model the appraised process includes the evaluation of the quality of work accomplished as well as reviews of work generated and work control outputs. In order to understand just what is reviewed a closer look at the work generation and work control sections is necessary.

The model of the work generation process is shown below:



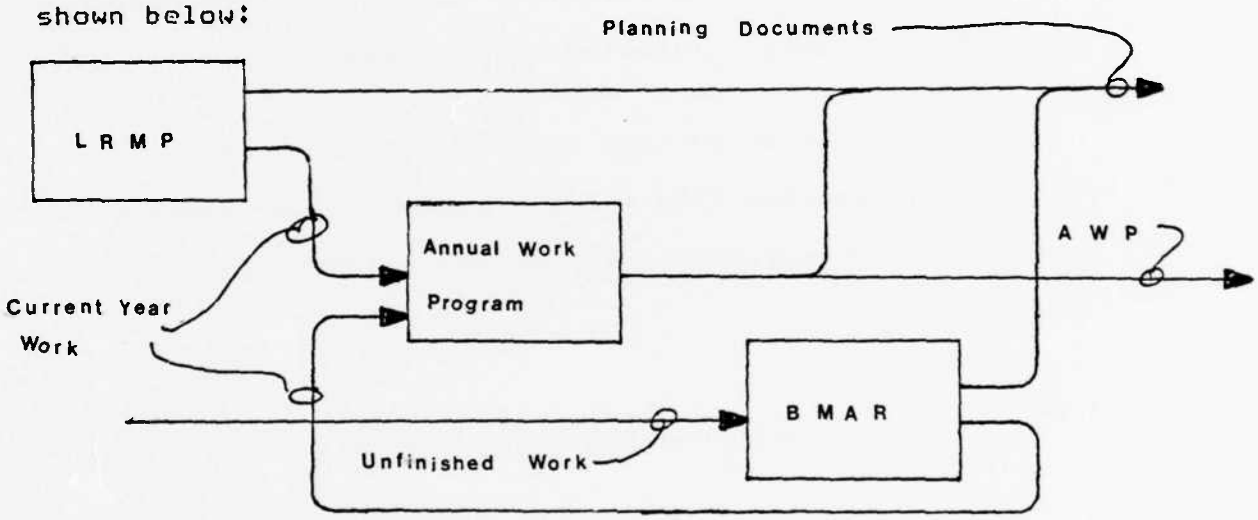
Work Generation Process

Figure IV-2

The tenant work requests are basically the work which tenants desire to have performed on their facilities. This can range from minor repairs to minor construction. These work requirements are a small portion of total work and are grouped with the results of the facility inspection process. The facility inspection process includes a physical inspection of each facility, and a listing of deficiencies with estimated repair costs and, if applicable, time frames when repairs are needed. Ideally, all facilities will be inspected in order to identify total work requirements. Additionally, the quality of the reports should be sufficiently accurate so that the cost requirements identified approximate the cost of repairs as they are actually per-

formed. The output from this work generation process is a listing of total work requirements.

The outputs from the work generation process feed into the work control process. The model for this process is shown below:



Work Control Process

Figure IV-3

As shown in the model, the total work requirements serve as a basis for the programming of all work. The long range maintenance plan serves to project resource requirements for the next five years. The annual work plan is an unconstrained scheduling of work required in the next fiscal year. This plan becomes the Annual Work Program as it is executed during the scheduled accomplishment phase. It is

constrained at that time by funds, manpower and materials available. At the end of the fiscal year , any unexecuted work is returned to the work control process to be included in the Backlog of Maintenance And Repair report. This report is assembled and forwarded to Headquarters Marine Corps for ultimate submission to congress.

Finally the inspection reports are maintained in a facility historical file for the purpose of developing an audit trail of modifications to, and condition of the facility.

RPMA Process Model Analysis

In the process of conducting Facilities Maintenance, the responsible officer would continuously monitor the various processes previously described. He would specifically concern himself with acquiring answers to the following questions:

1. What are the total deficiencies that require correction?
2. How is the workload programmed for accomplishment?
3. How is the Preventive Maintenance being conducted?
4. Which facilities require the most work?
5. How much money should be allocated for repair projects in future years?
6. At what level should this activity be funded to

prevent deterioration?

There are, as yet, no provisions for acquiring this information from the contractor. These points of information individually viewed do not evaluate performance. However, if they are collectively reviewed they can provide indications of completeness of the work identification, the thoroughness of the maintenance programming process, the commitment to work accomplishment and an overall feel for effectiveness. It is understood that these are not the only measures of effectiveness. These are measures that, if monitored regularly, will indicate how well the installation is being cared for.

Analysis of Organizational Considerations

With the increased emphasis on contracted Real Property Maintenance, measurement methods are required to evaluate the contractors RPM process, as well as the in house forces. Presently the in-house forces conduct the process as described in the RPMA Process model. Selecting effectiveness measures for them can be done from that model.

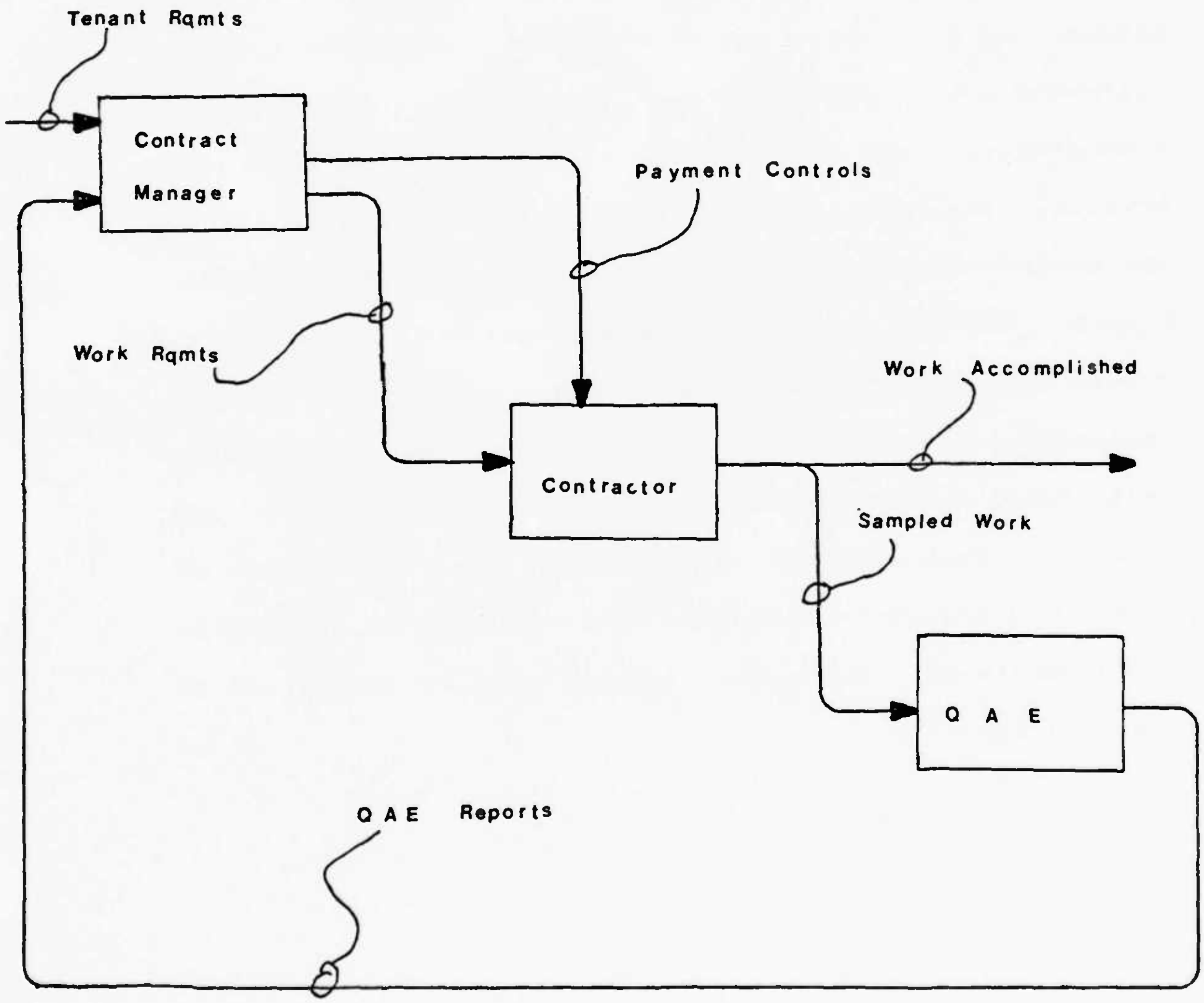
The contracted RPM process is, as yet, new enough that

provisions for the process evaluation have not been developed. Within the provisions of A-76, management functions that involve allocation or programming of federal funds must be performed by federal employees. This will mean that those work control functions that involve these functions must be performed by the maintenance officer's staff. Further discussion of this process as it relates to effectiveness will be contained in the proposed contract model section.

Descriptive Contracted Maintenance Model

Marine Corps Service contracts are presently administered through the nearest Naval Facilities Engineering Command's Officer In Charge of Construction (OICC). This is the only services contracting source available to Marine Corps RPMA's. Historically, the OICC administered the service contracts by coordinating with the maintenance branch as he felt necessary. Beginning in January 1982, the Marine Corps established a service contract administration section within the maintenance branch(CMCMSG 080017 z Jan 82). This section performs all aspects of service contract administration except the actual payment and modification of contracts. The essential informational flow of information between

manager and contractor is shown below:



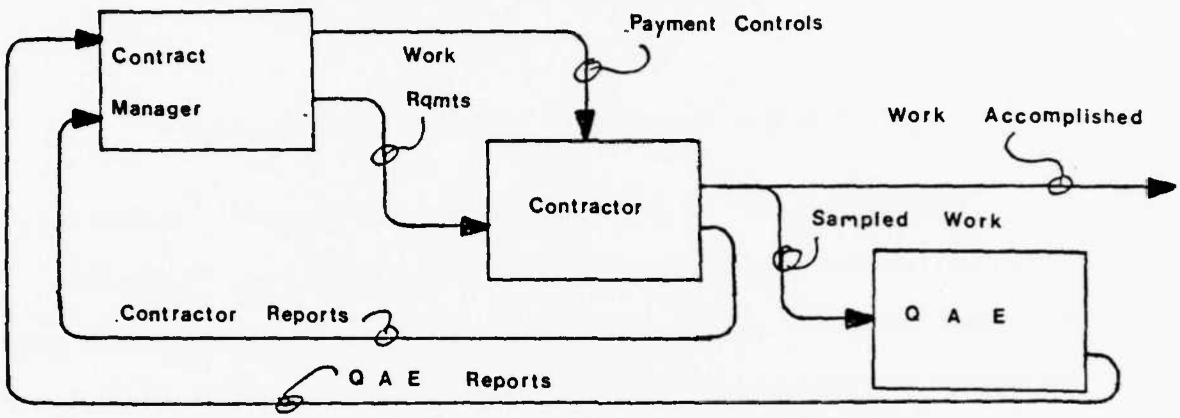
Present Contracted Maintenance Process

Figure IV-4

Descriptive Contracted Maintenance Model Analysis

As shown in the descriptive model, the communication between the contractor and the service contract manager is currently a transmittal of work requirements, contract interpretation and requests for clarification on contract details. The contractor's performance is monitored through the quality assurance evaluators attached to the maintenance branch. The contractor performance referred to here is the actual quality of the work performed. For example were replacement windows of the quality specified, or were pavement cracks sealed properly. However, with the use of new total maintenance operations contracts additional means of evaluating the contractor's performance will be necessary. The elements of information required will be identified in the next section.

Proposed Contracted Maintenance Model



Proposed Contracted Maintenance Process

Figure IV-5

In the above model provisions are included for the submission and evaluation of planning, programming and inspection of maintenance management documentation. The reports and files to be maintained, include the following areas:

Work schedules (monthly & yearly)
Workload programs (monthly)
Annual Inspections
Preventive Maintenance Inspections
Facility History files
Heating, Ventilation, and Air Conditioning standards
Preventive Maintenance standards

The reports to be submitted are defined in the proposed specifications contained in appendix D. These specifications are abstracted and modified from an existing Military Family Housing Maintenance Performance Statement of Work

(PSOW). (NAVFAC,1981) The reasons for selecting these areas for monitoring are presented in the same appendix.

Contract Specification Implementation

Implementation of this proposed contracted maintenance information system has two basic requirements. First the proposed specifications should be incorporated into the performance statement of work for the contract. The second requirement is that the Maintenance Officer's staff be instructed on the proper use of these reports. As these reports, or information contained in these reports, are currently being used in the Maintenance process, this should not be a new requirement for staff personnel.

Once these specifications are implemented, then the uniform evaluation of the maintenance process effectiveness can begin.

RPMA Effectiveness Measures Selection

The decisions that require support at the headquarters level are the same as those that were utilized for the contract maintenance process and the RPMA process; however the

level of detail does not need to be as refined. As there are many different factors influencing the RPMA, any corrective action initiated by the headquarters level managers should only be made after a careful review of the circumstances surrounding the problem. This is a particularly wise approach when one recalls that Headquarters level managers are only technical staffs for the commander (CMC, 1980). The facilities officer, on station, owes his primary allegiance, to the local commander (CMC, 1980). Any action taken by the facilities officer that impacts on the local commander must be approved by the local commander. Therefore the elements selected for the Effectiveness Measurement system will support the same types of decisions that the facilities officer will need to make, but with less resolution. These questions are:

1. Are the total deficiencies that require correction being identified?
2. How is the workload programmed for accomplishment?
3. To what degree is the preventive maintenance being conducted?
4. How confident can we be about the stated condition of the facilities?
5. How well does the base allocate money for local repair projects?
6. How should money be allocated for repair projects in future years?

Productivity

Productivity defined, both by DoD and the General Business Model, refers to efficient performance. That is, present performance compared to a standard either predetermined or from a previous period. Each activity is required, by Marine Corps Order, to prepare an Annual Work Plan and an Annual Work Program from the total work requirements of the work generation process. In the case of contracted maintenance, these documents would be prepared by the facilities officer's staff from inspection reports provided by the contractor. It is proposed that the productivity of the RFMA be measured by two means. The first would be a comparison of the portion of the Annual Work Program scheduled for the particular quarter to the work actually accomplished for the quarter. The measure would be computed as follows:

$$\frac{\text{Quarterly portion of the Annual Work Program accomplished}}{\text{Quarterly portion of the Annual Work Program scheduled}} \times 100 =$$

The second means would be a cumulative comparison of work accomplished to date to the total work identified on the Annual Work Program. The measure would be computed as follows;

$$\frac{\text{Total work accomplished to date}}{\text{Total Annual Work Program}} \times 100 =$$

Both of these measures address the output of the maintenance process, in man-hours, as compared to planned or programmed work. By comparing these two measures, the Headquarters level manager can determine how well the activity is moving toward it's established productivity goals. The first means will indicate the quarterly progress which should also be reflected in the second. There are occasions that would cause the first means to decline while the total effort would continue to increase.

Planning

The dimension of planning, as defined by Mahoney and Weitzel, involves the planning and scheduling of operations to avoid lost time. The total dimension includes the flexibility to be able to incorporate changes in the environment into operations (Mahoney and Weitzel, 1969). There are three proposed elements for this measure. The elements are:

% Facilities inspected year to date.
% Of Quarterly Work Plan taken from the unprogrammed sources.
% Of Quarterly Work Program taken from LRMP.

By evaluating these percentages, the headquarters level manager can determine how well the inspection process is working and how much of the work being programmed is actually coming from this process. In order to provide the facilities officer some flexibility in programming his work, to meet local conditions, it will be necessary to provide a programming goal that is less than 100%. This goal is presently set at 75% [CMC, 1980, p.4-11].

These elements can also be used in conjunction with the year end BMAR report to make a determination on where BMAR reduction problems are originating.

Reliability

The dimension of reliability, which is the ability to consistently meet objectives, can be measured most directly by two elements. These elements are the percentage of programmed quarterly expenditures actually made during the quarter, and the percentage of total expenditures programmed to those actually made, for the year to date. These two elements reveal the commitment of the activity to spend it's statutory maintenance floor. In the case of the activity

that might spend much less than 100% in the first quarter and then spend 200 or 300% in the final quarters,such action indicates either poor commitment to programmed spending or command influence to meet other priorities.

Initiation

The initiation component of this model will focus on the incremental change between quarters. The degree to which an organization can improve work methods and operations should be reflected in the increases or decreases in the previously identified performance measures. This system will identify the positive or negative changes in each of the summary level indicators of productivity, planning, and reliability. This will be accomplished by subtracting the last quarter's summary level indicators from the present quarter's respective indicator. The sum of these changes will then become the initiation factor for the quarter. Due to the constantly increasing design of the evaluation system, the first quarter of each fiscal year will have a value of zero for the initiation factor.

Overall Rating

The overall rating for this system will be constructed by multiplying the summary level indicators by their respective weighting factors and summing the results. The proposed format for this rating system is contained in Appendix B. It should be noted that each element computed is submitted on the report. The reason for this detail will be explained later in this chapter.

Simulation Models

Work Control Model

The work control model was constructed to simulate the planning and programming process conducted by an RPMA. This process, generically, involves the refining of estimates for the total work required and programming this work to be accomplished with funds and man-hours projected to be available during the upcoming fiscal year. The outputs of this process are the Annual Work Program and the Long Range Maintenance Plan(CMC,1980). The Annual Work Program serves as an input to the RPMA model to be described later.

Certain simplifying assumptions were made in the

construction of this simulation model. The first assumption was that the labor hours estimated would be normally distributed over a given range. This assumption was made due to the many unquantifiable factors that affect the actual estimation process. Additionally, all that was required for the simulation was a distribution of labor hours for each line item of the Annual Work Program. The next assumption was that the material costs for each line item would be normally distributed over a given range. This assumption was based on the same reasons as the labor hour assumption. An additional assumption made concerning this variable was that it's numerical value would be approximately six times that of the labor hours value. This assumption is based on the author's experience in the field. The material cost factor was empirically developed as a planning factor for budgeting purposes. In the field this factor was based on the labor cost, here a labor cost of one dollar per hour is also assumed for simplicity.

The process of assigning a work source code was based on the guidance provided by Headquarters Marine Corps. This guidance is that at least 75% of all hours available will be programmed for accomplishment. [CMC,1980,p. 4-11]. This guidance was implemented by using a normally distributed random number generator that generated numbers between one

and 0. If the number generated was less than .75 the line item was assigned a programmed source code. Any number between .75 and 1.0 was assigned an unprogrammed source code. Several assumptions, concerning variables used in both models were based on the size of the activity simulated. These variables are listed below:

Table IV-1

Base Size Variables

Variable	Base1	Base2	Base3
Number of Facilities	35	400	4000
Number of Facilities insptd/qtr	10	100	1000
Number of Annual Program LI	25	280	2800
% Work Accomplished In-house	90	90	70
% Work Accomplished by contract	10	10	30

Base Sizes

The three sizes of bases simulated are similar to actual Marine Corps activities. Henderson Hall, in the Washington area, has approximately 37 facilities(Henderson Hall contract). The Recruit Depot in San Diego California has approximately 399 facilities in it's inventory(Bowen, 1983). In the Pacific, Camp S.D. Butler has a facility inventory of approximately 4000 facilities.

Base Parameters

The number of Annual Work Program line items for each base was set at approximately 70% of the number of facilities in the inventory. This assumption was made in order to demonstrate the smoothing effects, if any, of a large line item program as opposed to a much smaller program.

The number of facilities inspected was initially obtained by dividing the total number of facilities by four. This assumed that the activity could inspect 25% of its facilities each quarter.

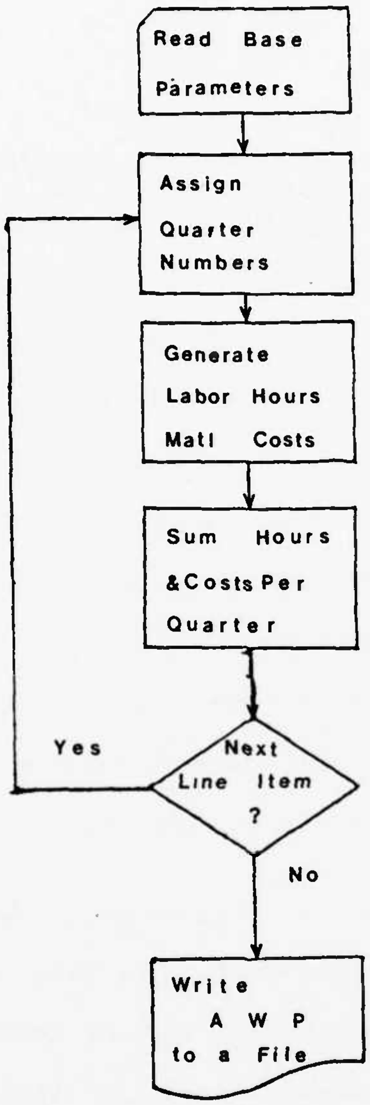
The percentage of in-house and contract work levels were initially established at a 90% in-house work for smaller bases because their work forces would be smaller and more responsive than repair contractors. The remaining 10% contract work accounted for normal service contracts such as grounds maintenance and refuse disposal. The effort levels for the large base indicate a reliance upon repair and service contractors to maintain the base. These levels of effort were selected as a result of the author's observations.

Funding Considerations

There have been occasions in the author's experience where previously unprogrammed funds became available to the RPMA. In an effort ot take advantage of these funds the RPMA would program between 110% and 120% of the budgeted funds. This overprogramming was possible through the use of shelf projects that would either be accomplished, in the event of additional funding or become part of the next year's Annual Work Program. These projects would normally be repair or service contracts that required funds only. In an effort to simulate this overprogramming, the work control model assigns a quarter number of 5 to approximately 20% of the Annual Work Program produced, and assigns a labor hour value of zero to these line items. This was to simulate contract repair or service that would normally absorb the excess monies received. Initial labor hours and funding levels were based upon the first four quarters of the Annual Work Program.

Work Control Simulation Model Translation

The work control model functions according to the flow chart shown in figure IV-6.



Work Control Simulation Model Flow Chart

Figure IV-6

Work Accomplishment Model

The Work Accomplishment model is based on the work accomplishment process of the RPMA. It's input variables consist of labor hours available, funding allocations from the base commander, the size of the base simulated, the Annual Work Program developed work control model, and the average number of facilities the activity expects to inspect for the quarter. The base size and the number of facilities inspected per quarter have been previously discussed. The labor hours and funding available will initially be established as the respective quarterly sums of the Annual Work Program. These variables will be manipulated in the experiments described in more detail in the next chapter.

The Annual Work Program, as previously described, contains a sequential program of work. In this model the Annual Work Program is an array or matrix that is six columns wide and as long as the number of line items requires. The computer knows it as AWP(m,6), where m is the number of line items required. The format of the array is described in the computer program shown in appendix D.

The Work Accomplishment Simulation Model accomplishes in line item sequence the work listed in the Annual Work Program array. It does this by insuring that funds and

hours (resources) are available to do the work, then accomplishing it. The resources are then diminished by the costs of the work accomplished. Accomplishing work out of sequence is not permitted in the model. It has been the author's experience that this is not an unreasonable assumption in that programming projects in the facilities maintenance process requires a certain amount of lead time before work can be accomplished or funded. In the case of repair contracts the contract and contract specifications can require lead times of up to a year for preparation. In the case of in-house accomplishment, funds can be allocated but work cannot begin until the materials have been procured. Material lead times vary significantly with the material procured, and can be as short as 24 hours or as long as six months. For these reasons the First-In-First-Out(FIFO) queing discipline was adopted.

Base Designations

In an effort to make an academic exercise more realistic, designations were assigned to each size base. In keeping with Marine Corps traditions, the designations for these bases were selected from the long list of prominent Marines in American History.

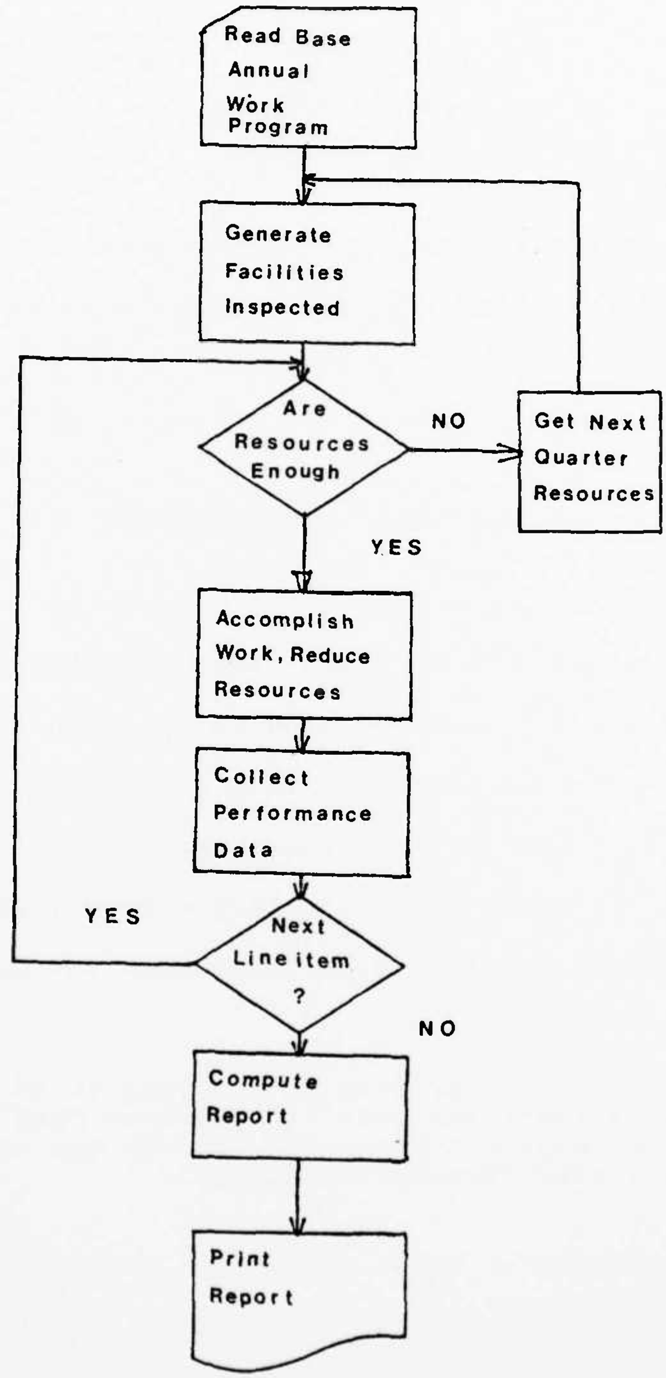
The smallest base, base1, is hereby designated "Camp Samuel Nicholas" after the first "Captain of Marines", a commission given in 1775 [Heinl, 1967, p.114]

The medium size base, base2, is hereby designated "Camp William W. Burrows" after the second commandant of the Marine Corps, appointed in 1798 [Heinl, 1967, p.114].

The largest base, base3, is hereby designated "Camp Presly N. O'Bannon" after the first Marine to raise the colors over the 'old world' after a feat of arms in 1805 [Heinl, 1967, p.114]. These designations will appear on the output of the RPMA simulation model.

Work Accomplishment Simulation Model Translation

The Work Accomplishment simulation model functions according to the flow chart shown in figure IV-7.



Work Accomplishment Simulation Model Flow Chart

Figure IV-7

Computerization

The simulations were programmed entirely in FORTRAN. The programs with their respective output are contained in appendix C.

Verification and Validation

Verification of these models was accomplished primarily by debugging the programs and hand calculating the results of decisions and calculations. This process revealed some small logic problems in the initial versions of the programs. These problems were corrected and the results checked for three separate simulation runs for Camp Nicholas.

> Validation is the process of bringing to an acceptable level the user's confidence that any inference about a system derived from the simulation is correct[Shannon,1975,p.29].

The validation of these simulation models will be presented in the next chapter during the analysis of the experiments.

CHAPTER V

THE EXPERIMENTS

Purpose of Experiments

The purpose of conducting the simulation is to demonstrate the ability of the effectiveness measurement system to identify problem areas within the RPM process. It is also intended to demonstrate the applicability of the system to bases of any size, or any method of maintenance performance.

How the Computer Runs Were Made

The simulation model was designed to accumulate performance data for a single year. A single run represented four report submissions. Each experiment was conducted eleven different times with a different random number seed used each time. The data summarized for each element of the experiment represents the mean value of the eleven runs for that element.

Sample Size Determination

The model constructed here represents a real system that has a multitude of environmental factors affecting the outcomes. Manny of the environmental factors have been addressed either by the model itself or by assumptions about the model. In order to obtain a 90% confidence level that the true results will be simulated here, a sample size of eleven was calculated to be sufficient. The sample size calculations are contained in appendix E.

The Baseline Experiment

The purpose of the baseline experiment is to produce report results for the activity as it performs at an optimum level. The optimum level was established as follows. Each base was funded in a timely manner with sufficient manhours to accomplish the programmed work within the quarter. The programming source code is within the established guide lines and the inspection process accomplishes approximately 25% of the total inspection requirement each quarter. Figure V-1 illustrates, in report format, the results of the overall rating for a fiscal year for the baseline

experiment. Comparison of the individual experiment elements with the respective baseline elements will be addressed in each experiment.

****

Camp Samuel Nicholas
(small)

Effectiveness Report No. 6

Element	First Qtr	Second Qtr	Third Qtr	Fourth Qtr
		Productivity Factors		
1	100.00	100.00	100.00	100.00
2	24.63	50.78	75.99	100.00
Sum	124.63	150.78	175.99	200.00
		Planning Factors		
3	22.42	47.05	70.40	93.30
4	9.09	9.09	9.09	12.73
5	74.55	74.55	80.00	72.73
	13	0.69	159.49	178.76
		Reliability Factors		
6	100.00	100.00	100.00	100.00
7	24.96	50.28	74.99	100.00
Sum	124.96	150.28	174.99	200.00
		Initiation Factors		
8	.00	76.10	78.72	68.29
Sum	.00	76.10	78.72	68.29
Rating	104.01	138.99	155.71	186.62

****

Baseline Experiment Report Summary
Figure V-1

It is important to note the similarity in the values for the productivity and reliability elements These two sections should increase from approximately 125% to approximately 200%, in increments of 25%. This indicates a constant level of activity regardless of how much work is programmed to be done during the quarter. Variations in these factors will be discussed in later experiments.

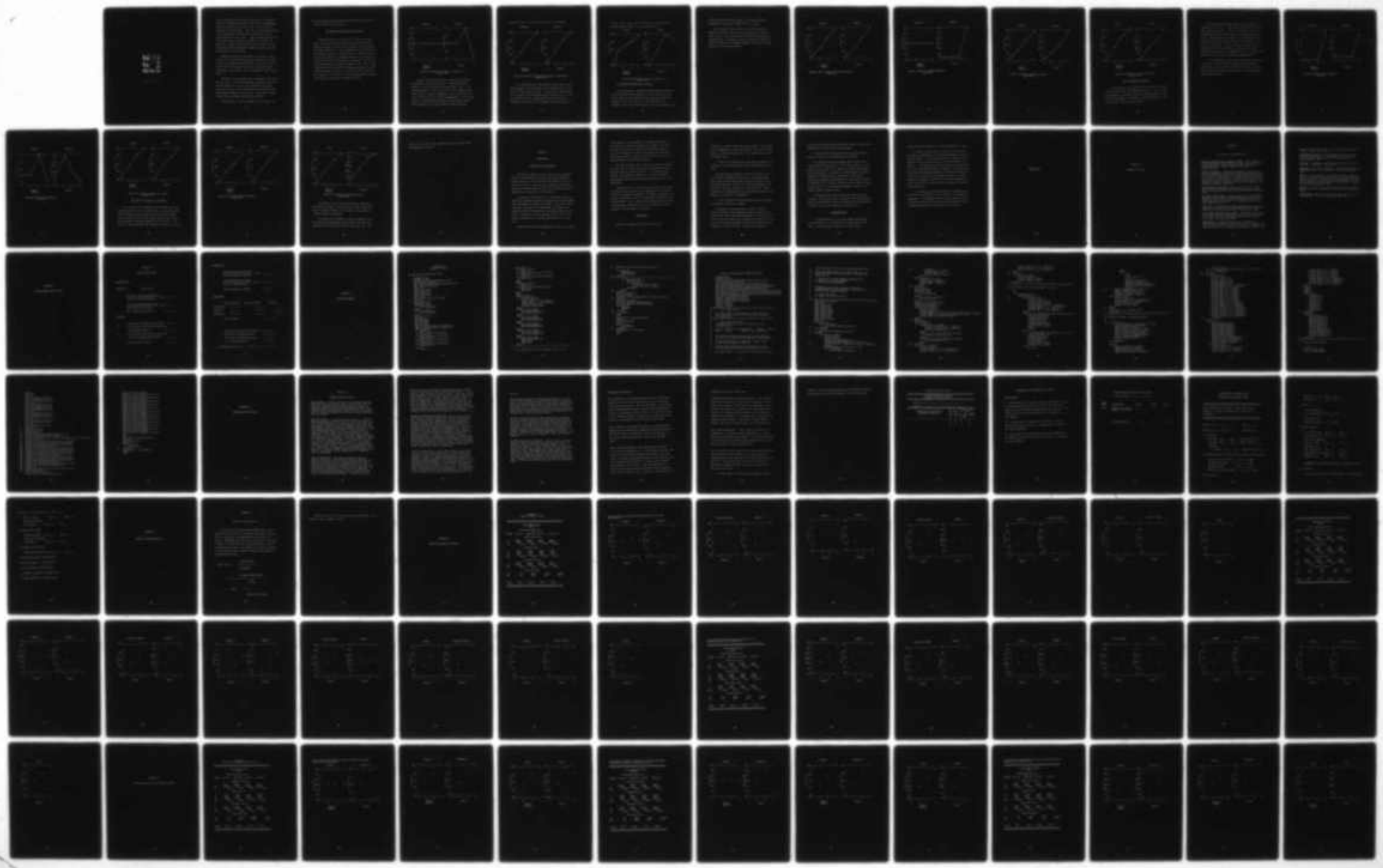
Element 3 is the inspection rate element. This element should increase over the year from 25% the first quarter to 100% in the fourth quarter. Under the assumption that a 100% inspection level will identify 95% of the deficiencies, a final value of 100% is desired in this element so that one has as many of the work requirements as possible. The gradual increase in even or about even increments, indicates a constant level of inspection effort. The constant level of inspection effort is an indication of a smooth functioning activity, where consistent emphasis is placed on the basic planning documents.

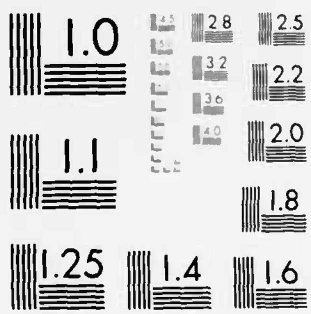
Elements four and five represent how well the planning documents are translated into actions. Element 4 shows the level of unprogrammed work that the activity is accomplishing. As long as these values are less than the established

AD-A134 949 EFFECTIVENESS MEASUREMENT IN THE MARINE CORPS REAL PROPERTY MAINTENANCE ACTIVITY(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF SYST.. W T MARSH

2/3

UNCLASSIFIED SEP 83 AFIT-LSSR-8-83 F/G 5/1 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

level of 25% there should be no real concern. Similarly, element 5 represents the level of work that was programmed. This value should be no less than 75% as established by Headquarters Marine Corps. The level at which these factors are set determines just how much flexibility the local maintenance officer will have. These two elements will vary over the course of the year, as shown in the graphs of appendix F. Smaller bases should display a wider variance than larger bases because they would have fewer line items in their annual work program.

Element 8 addresses improvement in the effort level over the year. Due to the increasing values built into the system, this element should constantly increase from zero. The graph of this element should show a positive slope. Variances in this element will be discussed in later experiments.

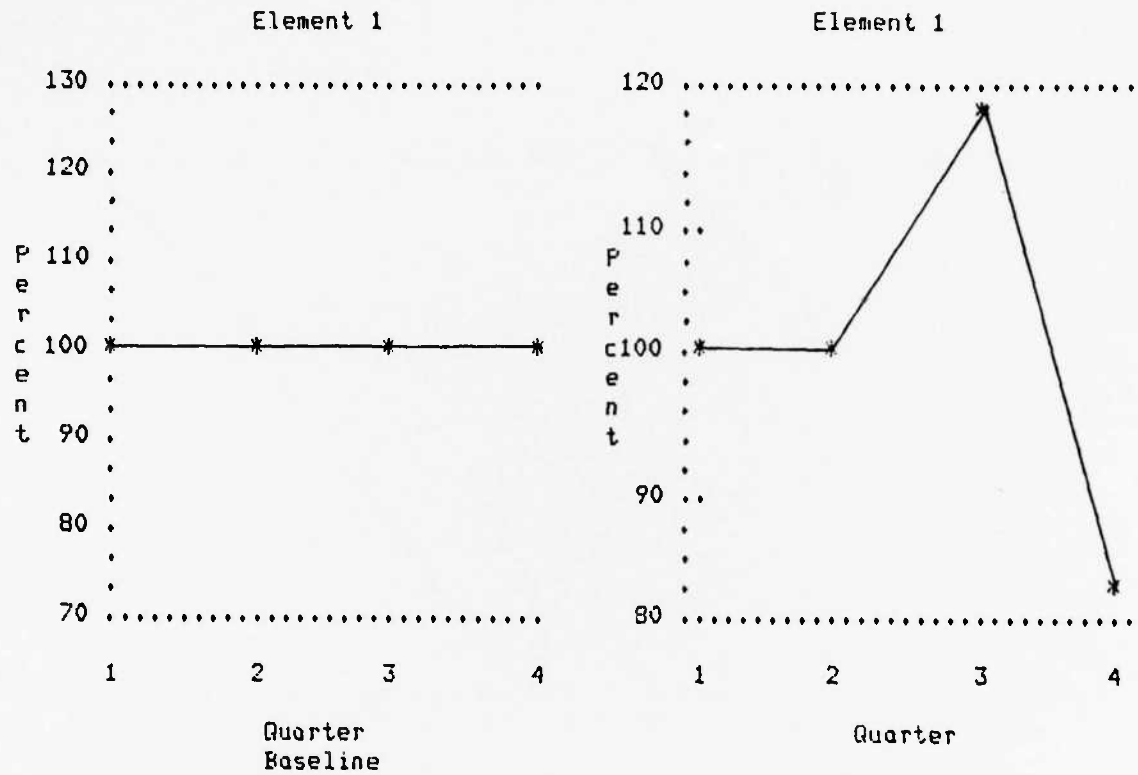
The overall rating should also be constantly increasing over the year. The graph should show a positive slope for all four quarters. As long as the graph has a positive slope the activity can be considered to be effective, even though other problem areas may exist. These other problem areas will be discussed later in this chapter.

The comparisons used as examples in this chapter will

be for the smallest base because the variations were more clearly defined for that base.

The Man-Hour Availability Experiment

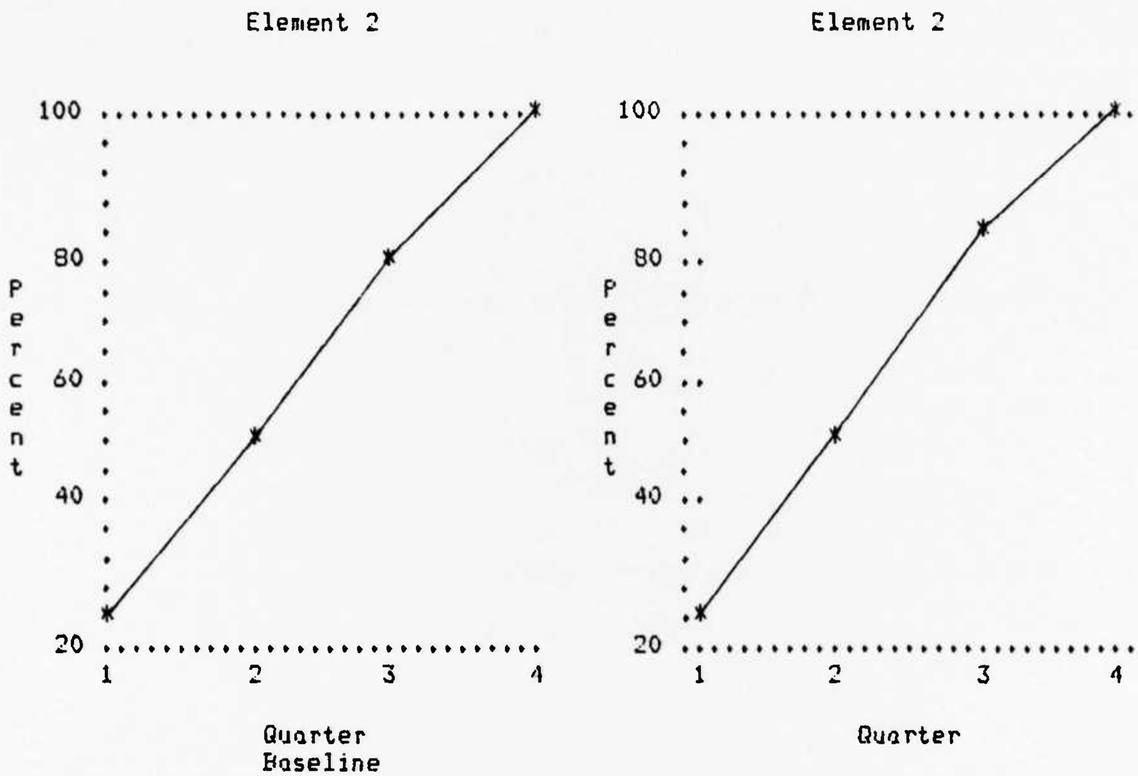
The availability of man-hours at an activity is normally limited to the authorized staffing of the activity. There are however, provisions for temporarily hired employees [CMC, 1980,p.3-6]. This experiment will be conducted by increasing the manhours available and providing an increase in the given quarter for material dollars. This will be a 10% increase in the annual budget allocations. The results of this experiment are shown in Figures V-2a, b and c. This figure displays the difference between the baseline results and the experiment results for both the overall rating and the productivity indicators. The following graphs represent the Man-Hour availability Experiment results.



Quarterly Completion Element, Experiment 2
Figure V-2a

Figure V-2a shows the effect of increasing man-hour availability in the third quarter. Note the peak that results in the third quarter and the drastic drop in the following quarter. This occurs due to the assumption that fifth quarter, or over programming, will be primarily contract work and not for in-house accomplishment. In the real system, an enterprising maintenance officer would create shelf projects for in-house forces if there were some

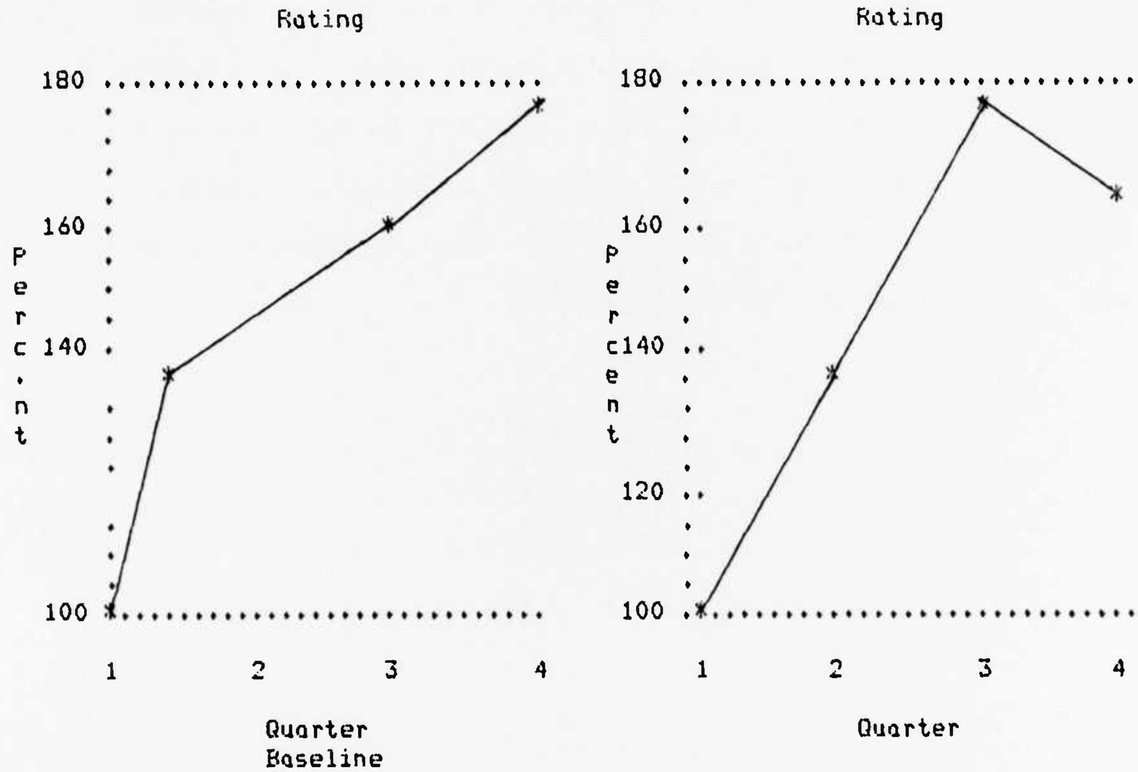
prospect for it. This is not always the case however.



Cumlulative Manhour Completion Element, Experiment 2
Figure V-2b

It is interesting to note that the radical peak in the first element is not reflected in the cumulative hours element (2) shown in Figure V-2b. It does have a marked effect on the overall rating element shown in Figure V-2c. It can be inferred from this experiment that unplanned labor increases in the labor force, whether civilian overhire or

military troop labor, will be reflected in the quarterly accomplishment element and the overall rating.



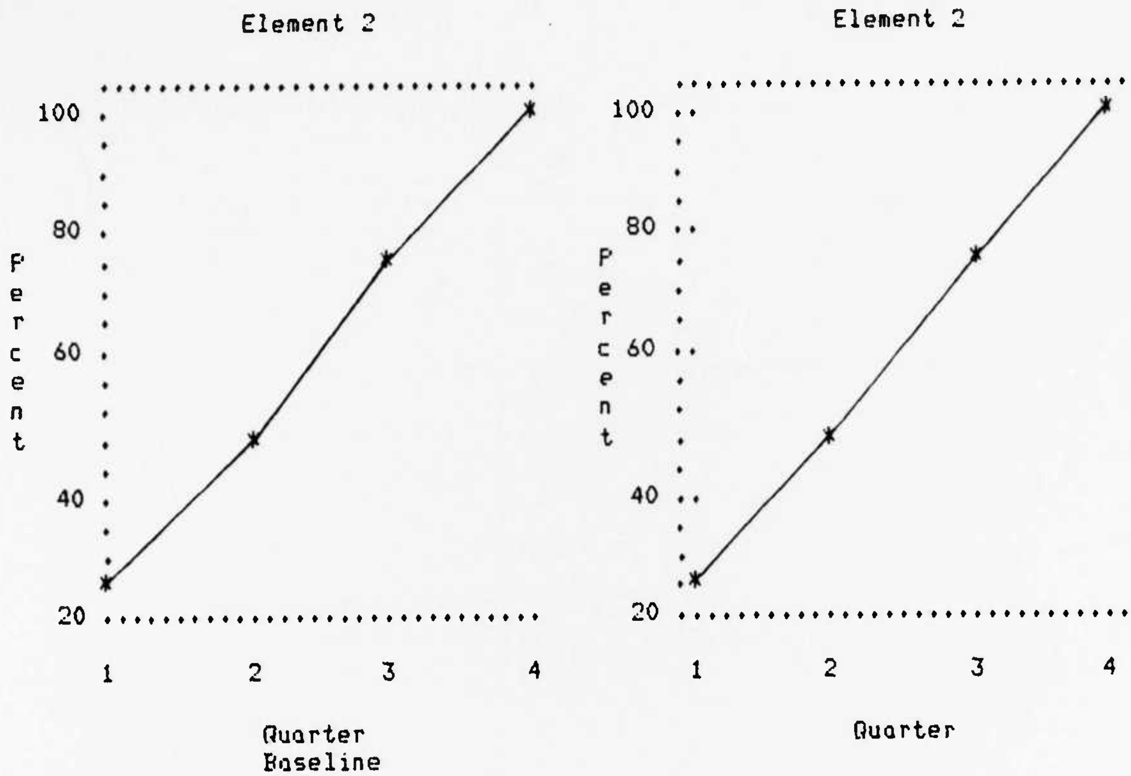
Man-Hour Availability Experiment(Rating)
Figure V-2c

The Funding Availability Experiment

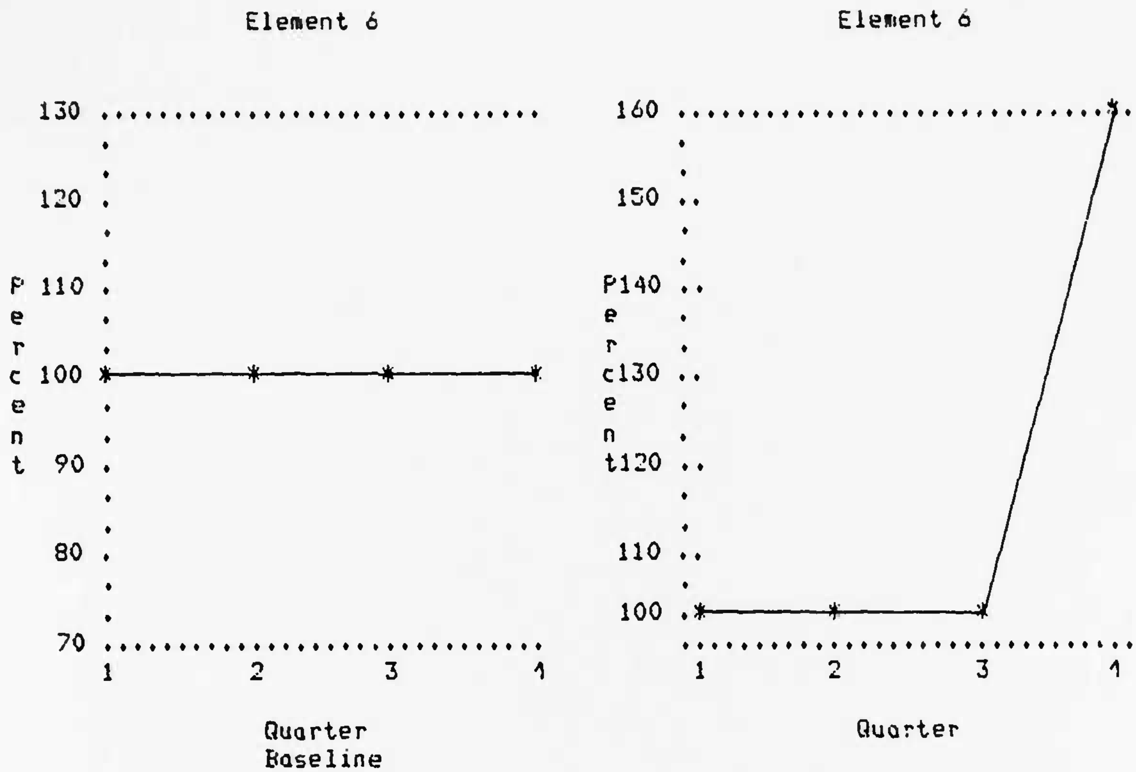
This experiment is intended to demonstrate the effects of applying additional funding in the last quarter of the fiscal year. In this experiment the additional funds were applied in the fourth quarter. These funds were not included in the Annual Work Program. The funds applied will

be 50% of the 5th quarter program. The results of this experiment are shown in Figures V-3a, b, c and d.

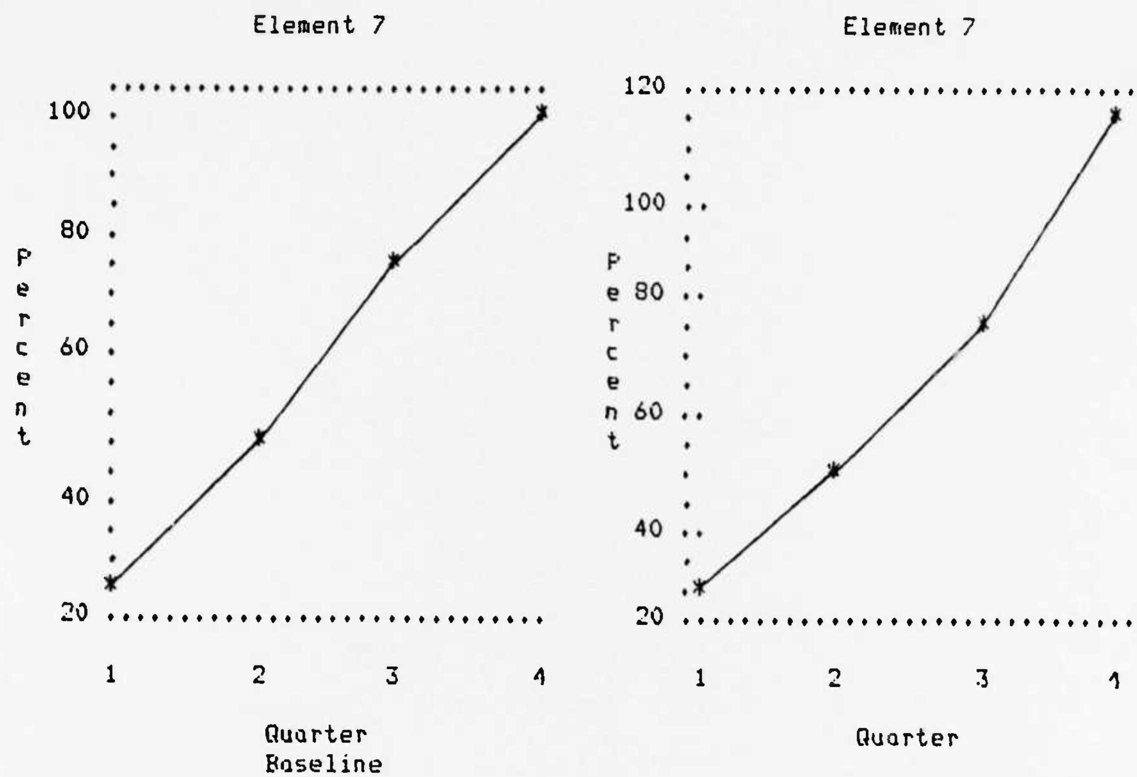
The increase or dump of funds in the fourth quarter shows an extremely sharp incline in the graphs of Figures V-3b, c and d. This sharp incline is not to be considered to a problem area. An activity that is constantly prepared to utilize windfall funds demonstrates both reliability and the ability to plan and think ahead.



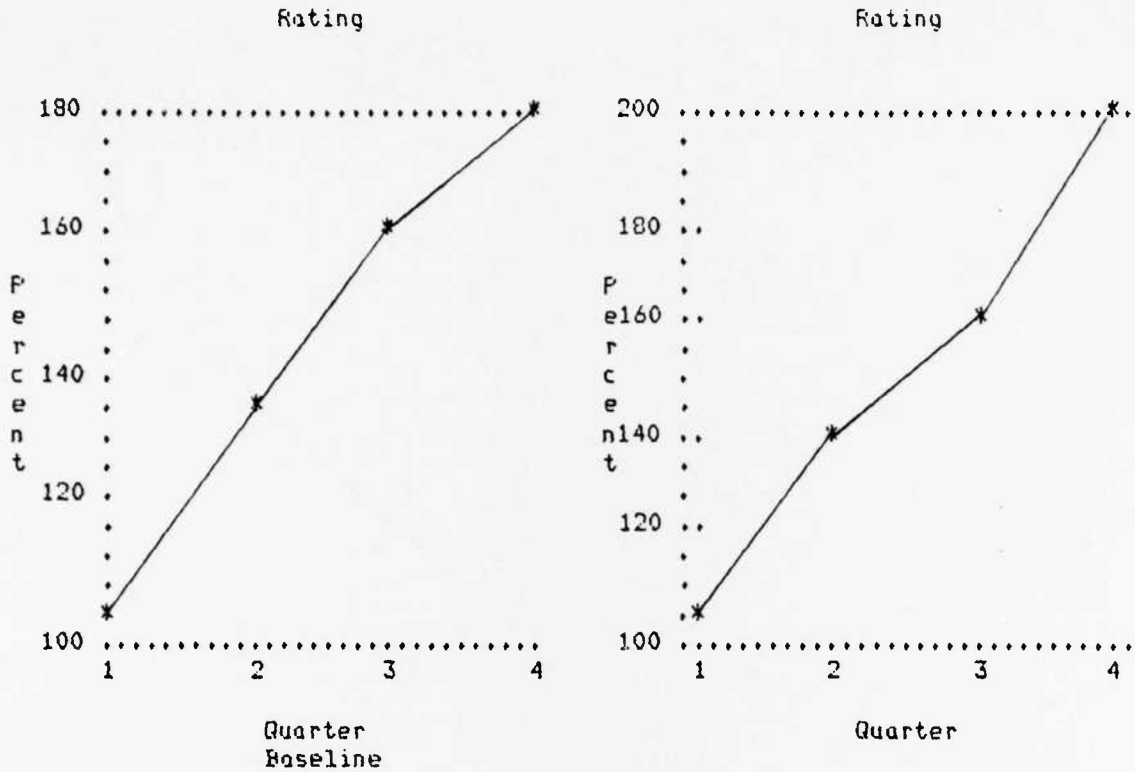
Cumulative Manhour Completion Element, Experiment 3
Figure V-3a



Quarterly Expenditure Element, Experiment 3
Figure V-3b



Cumulative Expenditure Element, Experiment 3
Figure V-3c



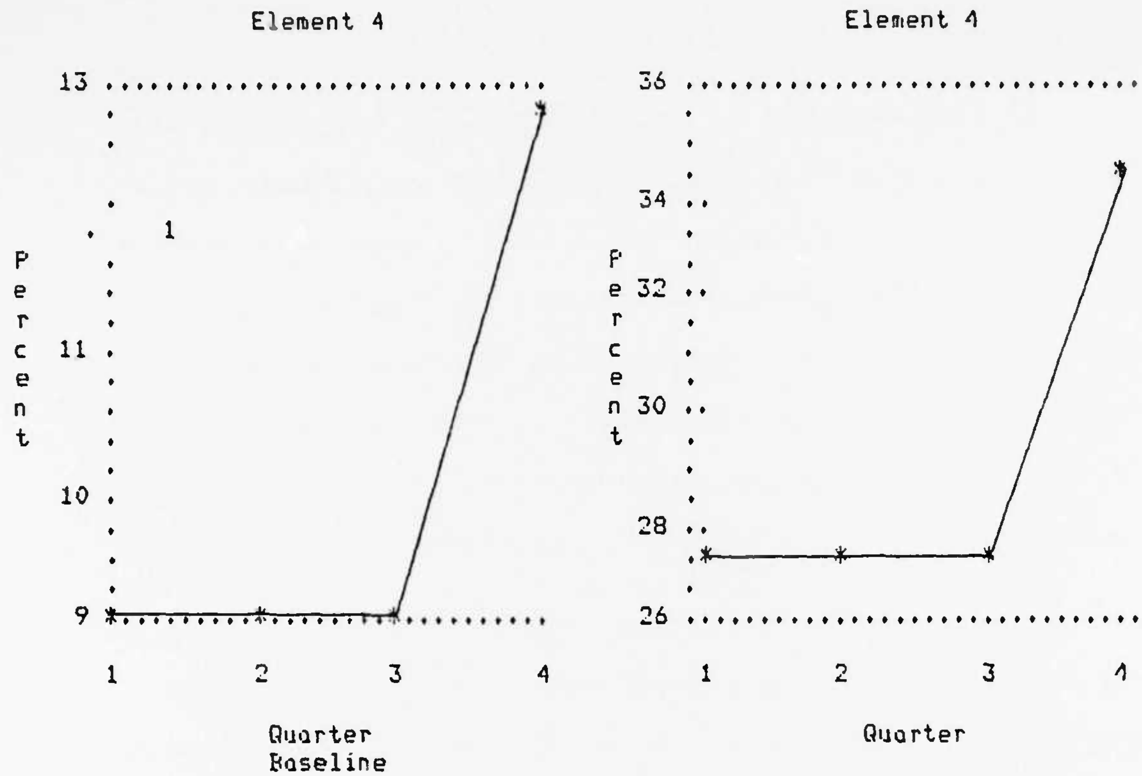
Funding Availability Experiment(Rating)
Figure V-3d

The Programming Experiment

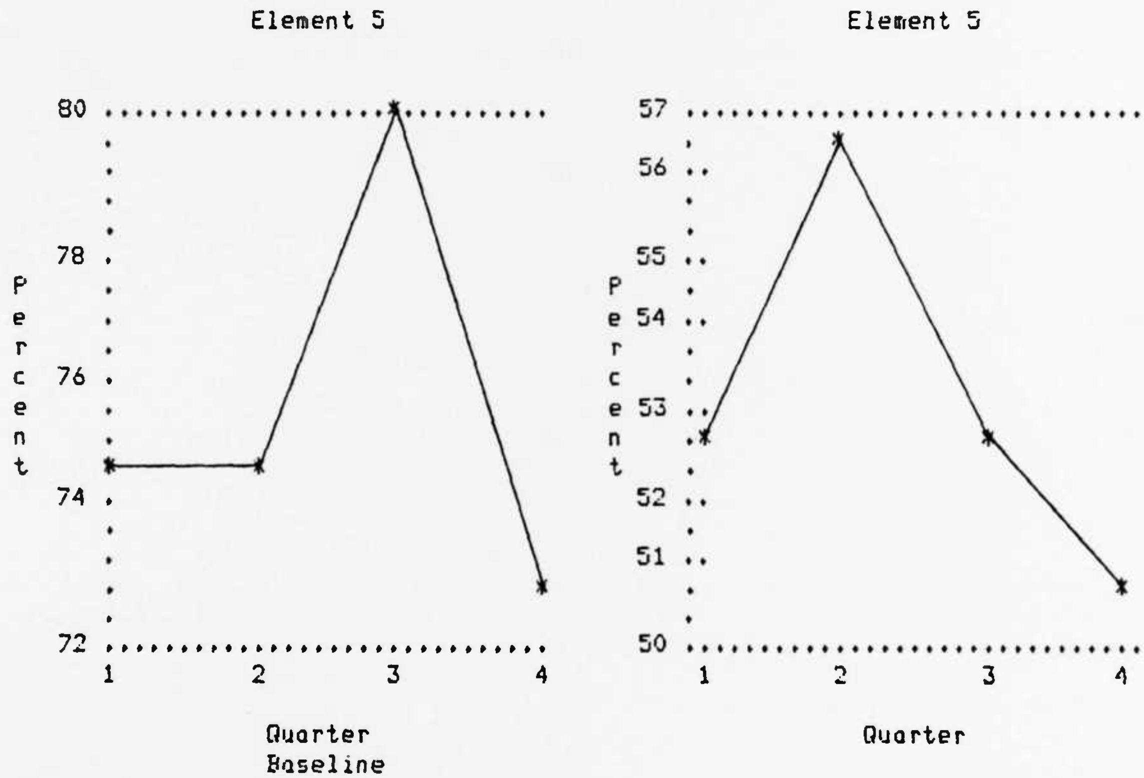
This experiment will demonstrate the effect of programming less than 75% of the budgeted resources. This will be accomplished by adjusting the source code parameters in the work control model. The effects of this experiment will be illustrated in Figures V-4a, b and c.

The programming experiment results are reflected in elements four and five. Figure V-4a and Figure V-4b reflect the results graphically. In these figures the levels of programmed and unprogrammed work exceed established guidelines. These graphs would indicate to a headquarters level manager that the particular activity is a little too flexible in its operation. There can easily be extenuating circumstances in this area however. Problems occasionally arise where the activity is required to assist in some local functions that may detract from the intended mission.

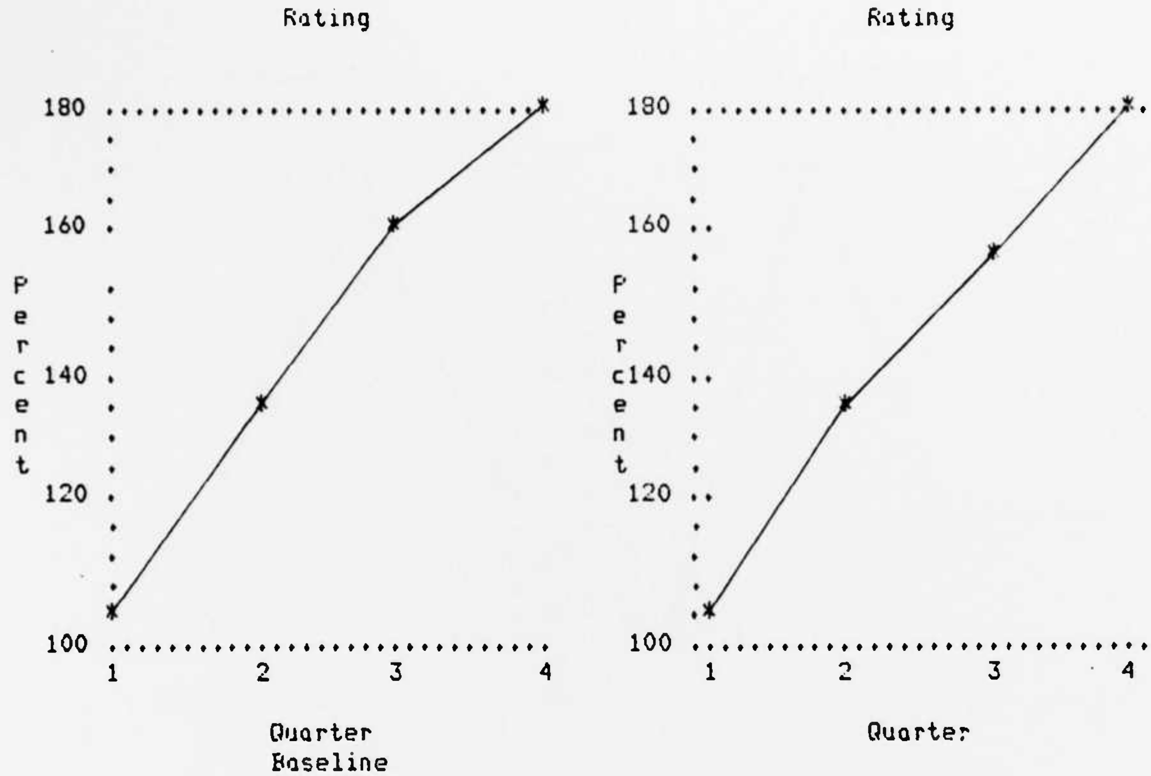
It is interesting to note that the overall rating does not reflect, to any noticeable degree, the programming shortfalls. This points out the the fact that this evaluation system should not be used to obtain a single number for effectiveness rating.



Unprogrammed Work Element, Experiment 4
Figure V-4a



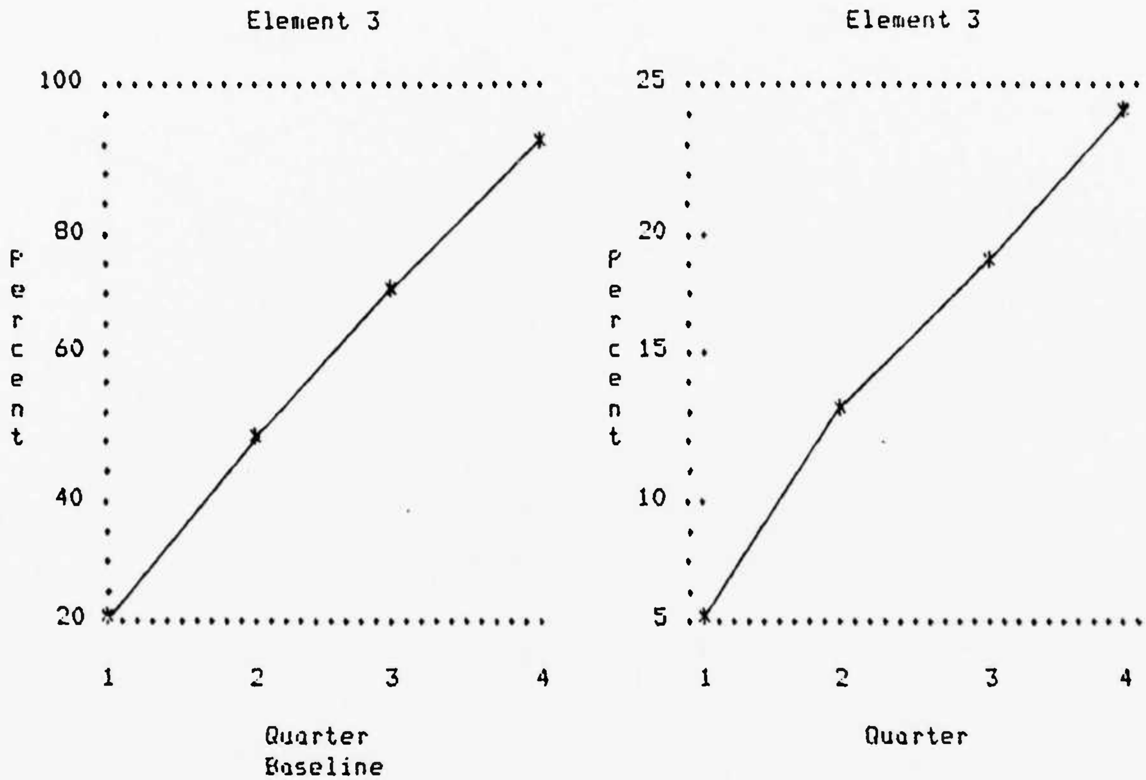
Programmed Work Element, Experiment 4
Figure V-4b



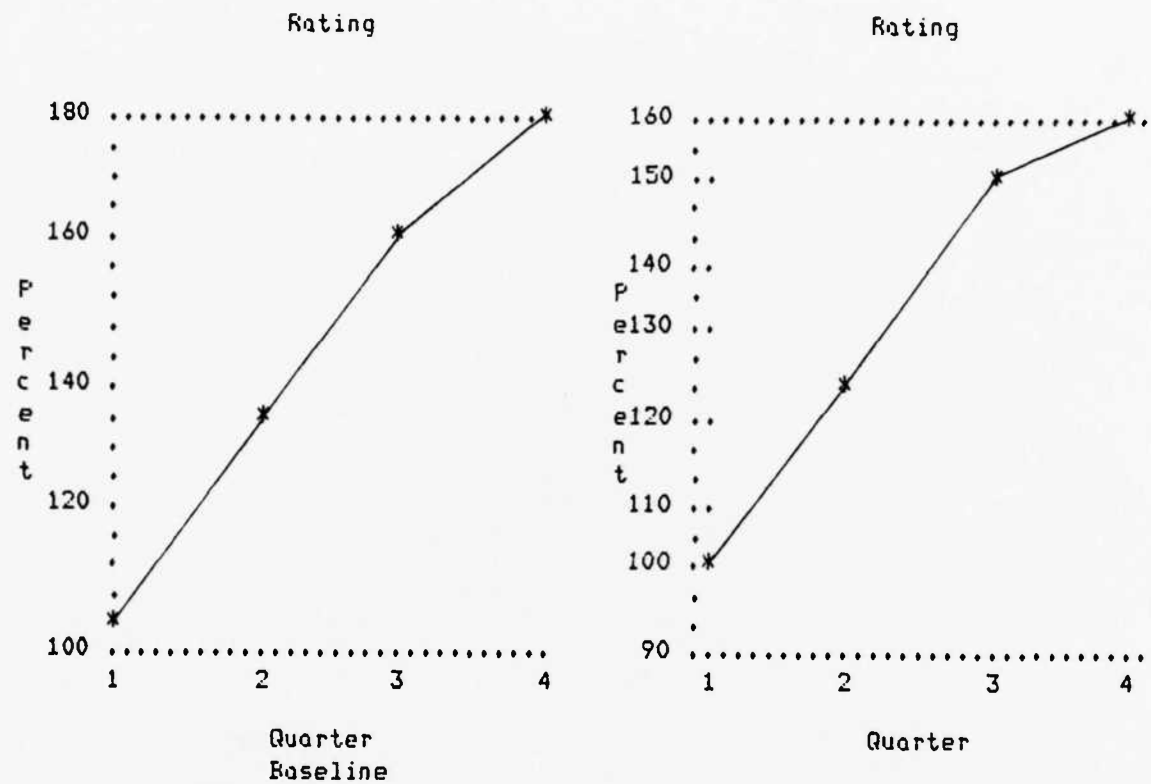
Level of Programming Experiment(Rating)
Figure V-4c

The Level of Inspection Experiment

This experiment will demonstrate the effects of a poor inspection program on the report results. The effectiveness of the inspection process coupled with the year end BMAR report and the overall rating, should provide some insight as to the BMAR or workload might be in future years. The results of the experiment are displayed in Figures V-5a and b.



Cumulative Inspection Element, Experiment 5
Figure V-5a



Level of Inspection Experiment(Rating)
Figure V-5b

The effects of this experiment manifest themselves in the graph of element 3 and the overall rating. Basically the only results apparent are decreases in the numerical value for these two elements.

The value of this element is that it provides a basis from which the headquarters level manager can assess the commitment to the planning process of the activity. The

theory here is that solid planning cannot be conducted from an incomplete data base.

CHAPTER VI

CONCLUSIONS

Overview and Limitations

The overall objective of this thesis was to identify a measure or combination of measures of effectiveness that enable managers to evaluate RPMAs reguardless of who provides the service. This objective included both defining measures of effectiveness for RPM, and developing a means of quantifying and reporting these measures.

In pursuit of that objective, a literature search was conducted. Research revealed an organizational effectiveness model developed by Mahoney and Weitzel. This linear regression model, the General Business Model, was empirically developed from the perceptions of managers in 283 organizations. The model, as used, consists of four primary components, productivity, planning, reliability, and initiation.

Before accounting data elements were selected as inputs

to this model, it was necessary to consider the impact of the commercial activities program on the RPMA. The result was that accounting and inspection information specifications were developed to permit the proposed effectiveness measurement system to apply to contractors that may in the future maintain Marine Corps Activities.

Once the contractor and in-house forces were collecting the same type of information, then the effectiveness measurement elements could be selected. The results of this process are contained in Appendix B. The effectiveness measurement system was evaluated through the use of a simulated RPMA.

The simulation is a rigid simulation which cannot simulate some of the unique and rare happenings at the various activities throughout the Corps. The model is adaptable for various size bases, and their corresponding methods of work accomplishment. From a statistical viewpoint the results of the experiments should predict to some extent, the actual values to be encountered in the field.

Conclusions

Within the limits of the simulation and the

experiments, several conclusions were reached. It is important to remember that these conclusions are based on a simulation and should be applied to a real system with caution and common sense.

1. How can an effectiveness measurement system be constructed for Marine Corps Real Property Maintenance Activities?

An effectiveness evaluation system for Marine Corps Real Property Maintenance Activities can be constructed. The system should be based upon Mahoney and Weitzel's General Business Model, and its four primary components, productivity, planning, reliability, and initiation. These components are compatible with current DoD directives on the subject of productivity enhancement.

2. What measures of effectiveness should be extracted from present information systems?

The effectiveness measurement system can utilize present planning and programming documents, except in the case of total base contracted maintenance. In this case, a set of contractor report specifications was prepared to permit the contracted maintenance process to be evaluated and compared to in-house forces. The primary information

sources are the activities Annual Work Program, and the data collected in the execution of that program.

3. How will the measurement system identify problem areas or efficiency and effectiveness shortfalls?

The proposed effectiveness measurement system identifies problem areas through the use of eight elements of the overall rating system. Each element represents some aspect of the RPM process. Variations in these elements are best determined through graphical renderings of the report results as compared to the baseline or steady state results. All elements do not directly impact upon the overall rating, so that analysis of the separate elements is necessary to identify general problem areas.

The simulation was most sensitive to labor hour fluctuations. This sensitivity is consistent with the weighting factors established by Mahoney's model and with DoD emphasis on labor as the primary measure of productivity.

Recommendations

1. Implementation of this effectiveness measurement system should be on a test basis for several size activities. A short period of instruction on the report

preparation process should, of course precede such a test.

2. Research identified a relatively new facilities evaluation system known as the Facilities Adequacy Scoring Technique(FAST). This system advocates the application of a numerical score to each facility, for both condition and adequacy. The incorporation of this process or even a part of it into the Mahoney model as presented in this thesis may well assist Marine Corps managers in evaluating how well an activity has performed its maintenance mission. Further research is needed in the areas of defining acceptable condition levels and in defining the term adequacy for Marine Corps facilities

3. Evaluation of the RFMAs using the proposed system should not be based solely on the results of the baseline experiment. An acceptable range of values should be established through the use of the baseline experiment and the consistent performance of the activity over time.

APPENDICIES

APPENDIX A

GLOSSARY OF TERMS

APPENDIX A

Definitions and Abbreviations

Backlog of Maintenance and Repair (BMAR). End of fiscal year measurement of maintenance and repair work remaining as a firm requirement of the annual plan but which lack of resources prohibit accomplishment in that fiscal year.(CMC,1980).

Control Inspection. Continuous inspection involving the periodic scheduled examination or test to determine the physical condition with respect to the maintenance standard of facilities, including utilities systems and installed equipment (class 2 real property), for the purpose of identifying deficiencies in the early stages of developement. The inspections generally pertain to electrical, mechanical and structural features.(CMC,1980).

Effectiveness measurement. Comparison of current performance against pre-established mission objectives (goals). Doing the right thing at the right time.(DoD Inst. 5010.34, p.10).

Efficiency measurement. Comparison of current performance against either a pre-established standard or actual performance of a prior period. Efficiency measurement can be based upon manpower, monies, or a combination of both.(DoD Inst. 5010.34, p. 10).

Facility. A seperate, individual building, structure, or other item of real property improvement which is subject to reporting under DoD real property inventory(CMC, 1980).

Long Range Maintenance Plan (LRMP). The LRMP is a forecast of all work required to maintain and repair the facilities of a shore activity in accordance with the established maintenance standards(CMC, 1980).

Maintenance. The recurrent day-to-day, periodic, or scheduled work required to preserve or restore a facility to such a condition that it may be effectively utilized for its designated purpose. Maintenance includes work undertaken to

prevent damage to a facility which otherwise would be more costly to restore(CMC, 1980).

Maintenance Standards. The established level at which facilities and grounds are maintained to assure maximum overall economy and protection of the Government's investment(CMC, 1980).

Overhead. Expenditures not directly chargeable to productive work in progress. (CMC, 1980).

Productive Time. Hours expended by maintenance personnel in the direct or actual performance of authorized work(CMC, 1980).

Repair. The restoration of a facility to such a condition that it may be effectively utilized for its designated purposes by overhaul, re-processing, or replacement of constituent parts or materials which have deteriorated by action of the elements or usage and which have not been corrected through maintenance(CMC, 1980).

Work Plan. All work required to meet maintenance standards during a specific time period, usually a fiscal year(CMC, 1980).

Work Program. Those portions of the work plan that can be accomplished with avaiable resources(CMC,1980).

APPENDIX B

EFFECTIVENESS REPORT FORMAT

Appendix B

EFFECTIVENESS REPORT

Productivity

Element no.	Computation
1.	$\frac{\text{Quarterly Program Accomplished}}{\text{Quarterly program Scheduled}} \times 100$ = ________
2.	$\frac{\text{Total work accomplished to date}}{\text{Total Annual work Program}} \times 100$ = ________
	Sum of Productivity Factors = ________

Planning

3.	% Facilities inspected this quarter = ________
4.	% Of Quarterly Work Program taken from unprogrammed sources = ________
5.	% Of Quarterly Work Program taken from The Long Range Maintenance Plan = ________
	Sum of Planning factors = ________

Reliability

6. Quarterly Expenditures Made / Qurtly expenditrs Scheduled X 100 = ________

$$\frac{\text{Quarterly Expenditures Made}}{\text{Qurtly expenditrs Scheduled}} \times 100 = \_\_\_\_\_\_\_\_$$

7. Total Expenditures to date / Totl Programmed Expendtrs X 100 = ________

$$\frac{\text{Total Expenditures to date}}{\text{Totl Programmed Expendtrs}} \times 100 = \_\_\_\_\_\_\_\_$$

Sum of Reliability factors = ________

Initiation

	Last Qtr factors	This Qtr factor	% Change
Productivity	_________	_________	_______
Planning	_________	_________	_______
Reliability	_________	_________	_______

Sum of changes = _______

.45 X Sum of Productivity Factors = ________

.25 X Sum of Planning Factors = ________

.17 X Sum of Reliability Factors = ________

.13 X Initiation Factor = ________

Effectveness rating for ____ Qtr Fy _____ = ________

APPENDIX C

COMPUTER PROGRAMS

Appendix C
Computer Programs

The work Control Simulation Model

```
      program maint
      parameter (m=25)
      integer nlin,swt,trace,seed,m,i,bb,d
      real normal,K,jobs(2,2)
      real AWP(m,6),dev,q,q2,q3,q4,q5,Qd(5),Qh(5)
      open (14,file='param1')
      rewind 14
      read (14,*) seed
      read (14,*) swt
      read (14,*) trace
      read (14,*) nlin
      do 5 i=1,2,1
      read (14,*) (jobs(i,K),K=1,2,1)
5     continue
      do 111 bb=1,11,1
      seed=seed + 167
      if(swt.eq.0)then
           call srand(seed)
      endif
      if(swt.eq.1)then
           call srand(seed)
      endif
      do 10 i=1,nlin,1
      q=nlin/5
      q2=(nlin/5)*2
      q3=(nlin/5)*3
      q4=(nlin/5)*4
      q5=(nlin/5)*5
      AWP(i,3)=normal(jobs(1,1),jobs(1,2))
      AWP(i,4)=normal(jobs(2,1),jobs(2,2))
      if(i.le.q)then
           AWP(i,1)=1
      elseif(i.gt.q.and.i.le.q2)then
           AWP(i,1)=2
      elseif(i.gt.q2.and.i.le.q3)then
           AWP(i,1)=3
      elseif(i.gt.q3.and.i.le.q4)then
           AWP(i,1)=4
      elseif(i.gt.q4.and.i.le.q5)then
           AWP(i,1)=5
      else
           endif
```

```
      dev=rand()
      if(dev.le..5)then
           AWP(i,5)=1
      elseif(dev.gt..5.and.dev.lt..7)then
           AWP(i,5)=2
      elseif(dev.gt..7.and.dev.lt.1.0)then
           AWP(i,5)=3
      else
      endif
      if(dev.le. .9)then
           AWP(i,6)=1
      elseif(dev.gt..9.and.dev.lt.1)then
           AWP(i,6)=2
           AWP(i,3)=0
      else
      endif
      AWP(i,2)=i*1.0
      if(trace.eq.1)then
           print*,'Trace #1'
           print*,'AWP(',i,',3)=',AWP(i,3)
           print*,'AWP(',i,',4)=',AWP(i,4)
           open(13,file='tracer')
           write(13,'(f8.5)')dev
      endif
      if(AWP(i,1).eq.1)then
           Qd(1)=Qd(1)+AWP(i,4)
           Qh(1)=Qh(1)+AWP(i,3)
      endif
      if(AWP(i,1).eq.2)then
           Qd(2)=Qd(2)+AWP(i,4)
           Qh(2)=Qh(2)+AWP(i,3)
      endif
      if(AWP(i,1).eq.3)then
           Qd(3)=Qd(3)+AWP(i,4)
           Qh(3)=Qh(3)+AWP(i,3)
      endif
      if(AWP(i,1).eq.4)then
           Qd(4)=Qd(4)+AWP(i,4)
           Qh(4)=Qh(4)+AWP(i,3)
      endif
      if(AWP(i,1).eq.5)then
           Qd(5)=Qd(5)+AWP(i,4)
           AWP(i,3)=0
           AWP(i,6)=2
      endif
c-----------------------------------------------------------
c
c   This section corrects for roundoff errors in the
```

```
c    computation of resources to be utilized.
c
      do 8 d=1,5,1
           Qd(d)=Qd(d)+2
           Qh(d)=Qh(d)+2
8     continue
c-----------------------------------------------------------
           if(trace.eq.1)then
                print*,'Trace #2'
                do 6 d=1,5,1
                     print*,'Qh(',d,')=',Qh(d)
                     print*,'Qd(',d,')=',Qd(d)
6               continue
           endif
10    continue
      open(12,file='sam1')
      do 20 i=1,nlin,1
      write(12,'(2f5.0,2f15.0,2f3.0)')(AWP(i,K),K=1,6,1)
20    continue
      open(12,file='sam1')
      write(12,'(5f15.0)')(Qd(d),d=1,5,1)
      write(12,'(5f15.0)')(Qh(d),d=1,5,1)
      do 21 d=1,5,1
           Qd(d)=0
           Qh(d)=0
21    continue
111      continue
      stop
      end
      real function normal(mean,stdv)
      integer i
      real aa,mean,stdv
      aa=0.0
      do 90 i=1,8,1
           aa=aa+rand()
90    continue
      normal=mean + (aa-6.0)*stdv
      return
      end
```

The Work Accomplishment Simulation Model

```
      program maint
      parameter (m=25)
      integer nlin,swt,trace,totfac,seed,m,i,k,j,x,n,aa,d
      real normal,Rate(4),dRate(4)
      real Facs,E11(5),E12(5),E13(5),E14(5),E15(5),E16(5)
      real E17(5),E18(5),sprodf(5),splanf(5),srelyf(5),sinitf(5)
      real dE11(5),dE12(5),dE13(5),dE14(5),dE15(5),dE16(5)
      real dE17(5),dE18(5),dsprod(5),dsplan(5),dsrely(5)
      real Qpachr(5,1),Qem(5,1),Twacdh(5),Texytd(5),hrsrm,dolrm,bcode
      real mean,stdv,AWP(m,6),resorc(2,5),facins(5),Tlup(5,1),e8d(3,5)
      real tawphr,tawpdl,Qtrhrs(5,1),Qtrdol(5,1),Tqln(5,1),Tlrmp(5,1)
      character camps(3)*25,size(3)*8
      camps(1)='Camp Sameul Nicholas'
      camps(2)='Camp William W. Burrows'
      camps(3)='Camp Presly N. OBannon'
      size(1)='(small)'
      size(2)='(medium)'
      size(3)='(large)'
c==============================================================
c           Array descriptions
c
c     The first number in the following arrays identifies
c     the fiscal year quarter within wich the information
c     is representing.
c==============================================================
c
c           Annual Work Plan (AWP)
c     The Annual Work Plan file is constructed in the
c     following manner.
c
c     Qtr  Line Item(lin) Man hours Matl$     Origin    Repair
c     Sched     Number          Required  Rqd  Code Code
c
c
c     The Qtr Sched column indicates the quarter that the
c     particular line item was scheduled for accomplishment.
c
c     The Line Item number is simply the sequence number
c     of the items included in the plan.
c
c     The Man hours required are the estimated hours that
c     will be required to correct the listed deficiency.
c
c     The Matl$ column is a listing of the estimated material
```

```
c     costs required to correct the identified deficiency.
c
c     The Origin Code column is an identification of the
c     source of origin for the line item.  The codes are
c     listed below;
c
c     1 = Source was the Long Range Maintenance Plan
c     2 = Source was Tennant requests
c     3 = Source was Unprogrammed
c
c
c     The Repair Code column provides the means of
c     accomplishment for the line item.  The codes are
c     listed in the following table;
c
c     1 = Local Work Force
c     2 = Repair or Service Contract
c
c===============================================================
      open (10,file='base1')
      rewind 10
      read (10,*) seed
      read (10,*) swt
      read (10,*) trace
      read (10,*) bcode
      read (10,*) totfac
      read (10,*) nlin
      read (10,*) mean
      read (10,*) stdv
      open (12,file='sam1')
      rewind 12
      do 5 aa=1,11,1
           do 92 j=1,nlin,1
                read (12,*) (AWP(j,k),k=1,6,1)
92         continue
      do 91 i=1,2,1
           read (12,*) (resorc(i,n),n=1,5,1)
91    continue
           if(trace .eq. 1)then
                do 93 i=1,4,1
                print*,'Trace # 1'
                print*,'Data for Quarter #',i
                print*,'Quarterly budget is $',resorc(1,i)
                print*,'Man Hours available this qtr=',resorc(2,i)
93              continue
                print*,'Number of line items =',nlin
                do 94 j=1,nlin,1
                     print*,(AWP(j,k),k=1,6,1)
```

```
94              continue
                print*,'Trace =',trace
                print*,'Swt =',swt
                print*,'Totfac =',totfac
            endif
        do 40 j=1,nlin,1
            if(AWP(j,1).lt.5)then
            tawphr=tawphr + AWP(j,3)
            tawpdl=tawpdl + AWP(j,4)
            endif
40      continue
        do 45 i=1,4,1
        seed=seed + 123
        if(swt.eq.0)then
            call srand(seed)
        endif
        if(swt.eq.1.and. i.eq.1)then
            call srand(seed)
        endif
        facins(i)=normal(mean,stdv)
        Facs=Facs + facins(i)
        E13(i)=(Facs/totfac)*100
        if(trace .eq. 3)then
            print*,'Trace #2'
            print*,'Quarter =',i
            print*,'Number of facilities inspected this Qtr= ',facins(i)
            print*,'Number of facilities inspected this Year= ',Facs
            print*,'Total facilities=',totfac
        endif
45      continue
        do 50 i=1,4,1
        do 55 j=1,nlin,1
            if(AWP(j,1) .eq. i)then
                Qtrhrs(i,1)=Qtrhrs(i,1) + AWP(j,3)
                Qtrdol(i,1)=Qtrdol(i,1) + AWP(j,4)
                Tqln(i,1)= Tqln(i,1) + 1
            endif
            if(AWP(j,1).eq.i.and. AWP(j,5).eq.1)then
                Tlrmp(i,1)=Tlrmp(i,1) + 1
            endif
            if(AWP(j,1).eq.i.and. AWP(j,5).eq.3)then
                Tlup(i,1)=Tlup(i,1) + 1
            endif
55      continue
        if(trace .eq. 1)then
            print*,'Trace # 3'
            print*,'Qtrhrs(',i,',1)=',Qtrhrs(i,1)
            print*,'Qtrdol(',i,',1)=',Qtrdol(i,1)
```

```
            print*,'Tqln(',i,',1)=',Tqln(i,1)
            print*,'Tlrmp(',i,',1)=',Tlrmp(i,1)
            print*,'Tlup(',i,',1)=',Tlup(i,1)
      endif
50    continue
      if(trace .eq. 1)then
            print*,'Trace # 4'
            print*,'tawphr=',tawphr
            print*,'tawpdl=',tawpdl
      endif
c=================================================================
c
c   Work Selection and Accomplishment Algorithim
c
      i=1
      j=1
            hrsrm=resorc(2,i)
            dolrm=resorc(1,i)
59                if(trace.eq.1)then
                        print*,'Trace # 5'
                        print*,'hrsrm=',hrsrm
                        print*,'dolrm=',dolrm
                        print*,'Resorc(2',i,')=',resorc(2,i)
                        print*,'Resorc(1',i,')=',resorc(1,i)
                        print*,'AWP(',j,',3)=',AWP(j,3)
                        print*,'AWP(',j,',4)=',AWP(j,4)
                  endif
                  if(hrsrm .ge. AWP(j,3).and.dolrm.ge.AWP(j,4))then
                        hrsrm=hrsrm-AWP(j,3)
                        dolrm=dolrm-AWP(j,4)
                        if(trace.eq.1)then
                        print*,'Trace # 6'
                        print*,'Quarter #',i
                        print*,'hrsrm=',hrsrm
                        print*,'dolrm=',dolrm
                        endif
                        go to 60
                  else
                        if(dolrm.ge.AWP(j,4).and.AWP(j,6).gt.1)then
                        hrsrm=hrsrm-AWP(j,3)
                        dolrm=dolrm-AWP(j,4)
                        if(trace.eq.1)then
                        print*,'Trace # 7'
                        print*,'Quarter #',i
                        print*,'hrsrm=',hrsrm
                        print*,'dolrm=',dolrm
                  endif
                        go to 60
```

```
                endif
                endif
                     i=i+1
                     x=i-1
                     if(i.gt.5)go to 71
                     j=j-1
                     dolrm=dolrm+resorc(1,i)
                     hrsrm=hrsrm+resorc(2,i)
                     Twacdh(i)=Twacdh(i)+Twacdh(x)
                     Texytd(i)=Texytd(i)+Texytd(x)
                     go to 71
60          Qpachr(i,1)=Qpachr(i,1)+AWP(j,3)
            Qem(i,1)=Qem(i,1)+AWP(j,4)
            Twacdh(i)=Twacdh(i)+ AWP(j,3)
            Texytd(i)=Texytd(i)+ AWP(j,4)
       if(trace.eq.1)then
            print*,'Trace # 8'
            print*,'Qpachr(',i,'1)=',Qpachr(i,1)
            print*,'Qem(',i,'1)=',Qem(i,1)
            print*,'Twacdh=',Twacdh
            print*,'Texytd=',Texytd
       endif
71     j=j+1
       if(i.gt.5.or.j.gt.nlin)go to 75
       go to 59
c=================================================================
c
c    Element and Rating  Computation Phase
c
c
75     do 80 i=1,4,1
            E11(i)=((Qpachr(i,1))/(Qtrhrs(i,1)))*100
            E12(i)=(Twacdh(i)/tawphr)*100
            sprodf(i)=E11(i)+E12(i)
            E14(i)=(Tlup(i,1)/Tqln(i,1))*100
            E15(i)=(Tlrmp(i,1)/Tqln(i,1))*100
            splanf(i)=E13(i)+E14(i)+E15(i)
            E16(i)=(Qem(i,1)/Qtrdol(i,1))*100
            E17(i)=(Texytd(i)/tawpdl)*100
            srelyf(i)=E16(i)+E17(i)
            x=i-1
       if(i.eq.1)then
            x=1
       endif
            e8d(1,i)=sprodf(i)-sprodf(x)
            e8d(2,i)=splanf(i)-splanf(x)
            e8d(3,i)=srelyf(i)-srelyf(x)
            E18(i)=e8d(1,i)+e8d(2,i)+e8d(3,i)
```

```
          sinitf(i)=E18(i)
     Rate(i)=(.45)*sprodf(i)+(.25)*splanf(i)+(.17)*srelyf(i)+
            (.13)*sinitf(i)
80   continue
     if(trace.eq.1)then
          do 70 K=1,4,1
          print*,'Trace # 9'
          print*,'hrsrm=',hrsrm
          print*,'dolrm=',dolrm
          print*,'Quarter #',K
          print*,'Qpachr(',K,',1)=',Qpachr(K,1)
          print*,'Qem(',K,',1)=',Qem(K,1)
          print*,'E11(',K,')=',E11(K)
          print*,'E12(',K,')=',E12(K)
          print*,'E13(',K,')=',E13(K)
          print*,'E14(',K,')=',E14(K)
          print*,'E15(',K,')=',E15(K)
          print*,'E16(',K,')=',E16(K)
          print*,'E17(',K,')=',E17(K)
          print*,'E18(',K,')=',E18(K)
          print*,'e8d(1,',K,')=',e8d(1,K)
          print*,'e8d(2,',K,')=',e8d(2,K)
          print*,'e8d(3,',K,')=',e8d(3,K)
          print*,'sprodf(',K,')=',sprodf(K)
          print*,'splanf(',K,')=',splanf(K)
          print*,'srelyf(',K,')=',srelyf(K)
          print*,'sinitf(',K,')=',sinitf(K)
          print*,'Twacdh(',K,')=',Twacdh(K)
          print*,'Texytd(',K,')=',Texytd(K)
70        continue
     endif
     do 72 d=1,4,1
          dE11(d)=dE11(d)+E11(d)
          dE12(d)=dE12(d)+E12(d)
          dE13(d)=dE13(d)+E13(d)
          dE14(d)=dE14(d)+E14(d)
          dE15(d)=dE15(d)+E15(d)
          dE16(d)=dE16(d)+E16(d)
          dE17(d)=dE17(d)+E17(d)
          dE18(d)=dE18(d)+E18(d)
          dsprod(d)=dsprod(d)+sprodf(d)
          dsplan(d)=dsplan(d)+splanf(d)
          dsrely(d)=dsrely(d)+srelyf(d)
          dRate(d)=dRate(d)+Rate(d)
     if(trace.eq.1)then
          print*,'Trace # 10'
          print*,'dE11(',d,')=',dE11(d)
          print*,'dE12(',d,')=',dE12(d)
          print*,'dE13(',d,')=',dE13(d)
```

```
            print*,'dE14(',d,')=',dE14(d)
            print*,'dE15(',d,')=',dE15(d)
            print*,'dE16(',d,')=',dE16(d)
            print*,'dE17(',d,')=',dE17(d)
            print*,'dE18(',d,')=',dE18(d)
            print*,'dsprod(',d,')=',dsprod(d)
            print*,'dsplan(',d,')=',dsplan(d)
            print*,'dsrely(',d,')=',dsrely(d)
            print*,'dRate(',d,')=',dRate(d)
      endif
72    continue
      Facs=0
      tawphr=0
      tawpdl=0
      do 74 d=1,5,1
            Qtrhrs(d,1)=0
            Qtrdol(d,1)=0
            Tqln(d,1)=0
            Tlrmp(d,1)=0
            Tlup(d,1)=0
            Twacdh(d)=0
            Texytd(d)=0
            Qem(d,1)=0
            Qpachr(d,1)=0
74    continue
5     continue
      do 73 d=1,4,1
            dE11(d)=dE11(d)/11
            dE12(d)=dE12(d)/11
            dE13(d)=dE13(d)/11
            dE14(d)=dE14(d)/11
            dE15(d)=dE15(d)/11
            dE16(d)=dE16(d)/11
            dE17(d)=dE17(d)/11
            dE18(d)=dE18(d)/11
            dsprod(d)=dsprod(d)/11
            dsplan(d)=dsplan(d)/11
            dsrely(d)=dsrely(d)/11
            dRate(d)=dRate(d)/11
73    continue
c==============================================================
c
c    Formatted Report Output
c
c
      print 8
      print 9,camps(bcode)
      print 10,size(bcode)
```

```
      print 11
      print 13
      print 12
      print 15,(dE11(i),i=1,4,1)
      print 16,(dE12(i),i=1,4,1)
      print 17,(dsprod(i),i=1,4,1)
      print 18
      print 20,(dE13(i),i=1,4,1)
      print 21,(dE14(i),i=1,4,1)
      print 22,(dE15(i),i=1,4,1)
      print 23,(dsplan(i),i=1,4,1)
      print 24
      print 25,(dE16(i),i=1,4,1)
      print 26,(dE17(i),i=1,4,1)
      print 28,(dsrely(i),i=1,4,1)
      print 29
      print 30,(dE18(i),i=1,4,1)
      print 31,(dE18(i),i=1,4,1)
      print 32
      print 34,(Rate(i),i=1,4,1)
      print 35
8     format(/,65('*'))
9     format(/,19x,a25)
10    format(25x,a8)
11    format(/,15x,'Effectiveness Report No. 6')
12    format(/,20x,'Productivity Factors')
13    format(/,'Element',3x,'First Qtr',4x,'Second Qtr',2x,'Third Qtr',
     +5x,'Fourth Qtr')
15    format(/,1x,'1',8x,f6.2,7x,f6.2,7x,f6.2,7x,f6.2)
16    format(1x,'2',8x,f6.2,7x,f6.2,7x,f6.2,7x,f6.2)
17    format('Sum',12x,f6.2,7x,f6.2,7x,f6.2,7x,f6.2)
18    format(/,20x,'Planning Factors')
20    format(/,1x,'3',8x,f6.2,7x,f6.2,7x,f6.2,7x,f6.2)
21    format(1x,'4',8x,f6.2,7x,f6.2,7x,f6.2,7x,f6.2)
22    format(1x,'5',8x,f6.2,7x,f6.2,7x,f6.2,7x,f6.2)
23    format('Sum',12x,f6.2,7x,f6.2,7x,f6.2,7x,f6.2)
24    format(/,20x,'Reliability Factors')
25    format(/,1x,'6',8x,f6.2,7x,f6.2,7x,f6.2,7x,f6.2)
26    format(1x,'7',8x,f6.2,7x,f6.2,7x,f6.2,7x,f6.2)
28    format('Sum',12x,f6.2,7x,f6.2,7x,f6.2,7x,f6.2)
29    format(/,20x,'Initiation Factors')
30    format(/,1x,'8',f15.2,1x,f15.2,1x,f15.2,1x,f15.2)
31    format('Sum',f15.2,f15.2,f15.2,f15.2)
32    format(//)
34    format('Rating',6x,f6.2,7x,f6.2,7x,f6.2,7x,f6.2)
35    format(/,65('*'))
      open (17,file='report1')
      write(17,'(f6.2)')(dE11(d),d=1,4,1)
```

```
      open (17,file='report2')
      write(17,'(f6.2)')(dE12(d),d=1,4,1)
      open (17,file='report3')
      write(17,'(f6.2)')(dsprod(d),d=1,4,1)
      open (17,file='report4')
      write(17,'(f6.2)')(dE13(d),d=1,4,1)
      open (17,file='report5')
      write(17,'(f6.2)')(dE14(d),d=1,4,1)
      open (17,file='report6')
      write(17,'(f6.2)')(dE15(d),d=1,4,1)
      open (17,file='report7')
      write(17,'(f6.2)')(dsplan(d),d=1,4,1)
      open (17,file='report8')
      write(17,'(f6.2)')(dE16(d),d=1,4,1)
      open (17,file='report9')
      write(17,'(f6.2)')(dE17(d),d=1,4,1)
      open (17,file='report10')
      write(17,'(f6.2)')(dsrely(d),d=1,4,1)
      open (17,file='report11')
      write(17,'(f6.2)')(dE18(d),d=1,4,1)
      open (17,file='report12')
      write(17,'(f6.2)')(dE18(d),d=1,4,1)
      open (17,file='report13')
      write(17,'(f6.2)')(dRate(d),d=1,4,1)
      stop
      end
      real function normal(mean,stdv)
      integer i
      real aa,mean,stdv
      aa=0.0
      do 90 i=1,4,1
           aa=aa+rand()
 90   continue
      normal=mean + (aa-6.0)*stdv
      return
      end
```

APPENDIX D

PROPOSED SPECIFICATIONS

Appendix D

Proposed Specifications

WORK SCHEDULE. Monthly and yearly work schedules shall be provided to OIC for approval within 10 days after contract award for continuing work such as Janitorial Services, Grounds Maintenance Services, Pest Control Services, PM Inspection Services and Annual Inspection Services. These services shall be provided by the contractor in accordance with the approved schedule and require no further authorization by the OIC.

WORKLOAD PROGRAM. The contractor will submit to the OIC a monthly workload p rogram by the 25th day of each month for the following 60 days. This plan will list by priority all items of work scheduled for accomplishment during the next two months. It will include all routine service calls with an estimated time for completion exceeding four hours. Work requirements generated as a result of the contractor's annual inspection effort shall also included and listed separately. Work listed on the workload program must by completed within 60 days after it has been identified either by inspection or by occupant. Items on the workload program must include a manhour estimate for accomplishment, as well as a start and completion date. All work will be accomplished utilizing a work authorization form. Work authorizations will be utilized for each facility individually or for common items of work. Work can be aggregated by facility or building. For example, one work authorization can be utilized for common sidewalk repairs, HVAC distribution systems in a building or screen replacement in a number of units or buildings.

ANNUAL INSPECTIONS. All grounds, sidewalks, fences, drainage systems and other related facilities and real property not covered in any of the inspections described in previous paragraphs, shall be inspected once each year. Appendix A is provided as a suggested format for recording all the deficiencies identified during the inspection. The deficiencies identified as a result of this inspection, which do not constitute a major repair as defined herein, shall be scheduled for correction in accordance with the provisions of the workload program. The contractor shall

provide an annual facilities inspection schedule for approval by the OIC within 10 days after contract award. The schedule shall reflect a minimum of 25% of facilities assets being inspected in each of the first four months and provide for completion of all annual inspections within four months after contract award. A copy of each inspection report shall be submitted to the OIC within three working days of date of inspection. The original shall be retained in the facility history file. Real property maintenance requirements identified by the contractor or the occupant after the first six months of the contract period are also the responsibility of the contractor and are to be accomplished through normal work control procedures or as a service call.

PREVENTIVE MAINTENANCE INSPECTIONS. Within 10 days after the contract award date, the contractor shall provide the OIC a written one-year schedule, by month, for performing preventive maintenance inspections. These inspections include cleaning, adjusting,lubricating and making corrections to the heating, ventilation and air conditioning equipment of each facility on a periodic basis. Air conditioning preventive maintenance inspections shall be performed once on each facility during the period! (specify period)!. Heating preventive maintenance inspections shall be performed once on each unit during the period of ! (specify period)!. Preventive maintenance inspections and maintenance shall be performed in accordance with the standards established in HVAC standards paragraph, the FM standards paragraph and an inspection report shall be completed for each unit inspected. A copy of these inspection reports shall be submitted to the OIC within three working days after the inspection has been completed.

FACILITY HISTORY FILES. A facility history file for each facility identified by address shall be maintained by the contractor. Each file shall contain a copy of the annual inspection report and preventive maintenance inspection reports. A copy of all work authorizations in progress or completed shall be included in the file along with a list of Government-owned equipment. The contractor shall also maintain all warranty information and furnishing inventories complete with serial numbers in this file. The Government shall require access to these files and they shall be available for periodic review by the Government . All documents shall be filed within 10 days of completed transaction and finally turned over the Government upon completion of the

contract.

COST ACCOUNTING SYSTEM/ REPORTING REQUIREMENTS. The contractor shall maintain and provide cost accounting information using an organized job ordering system with sufficient detail to comply with the specific requirements detailed in the section titled "Contractor's Maintenance Cost Report". The contractor will furnish the contract manager this report monthly which will enable the activity to provide necessary cost reports to higher authority and allow the monitoring of expenditures by the Maintenance Officer.

HEATING VENTILATION AND AIR CONDITIONING (HVAC) STANDARDS. The work includes inspecting and maintaining heating, air conditioning and ventilating systems in good safe operating condition. All materials and equipment furnished shall be the same type, grade, quality and size as the original construction. The contractor shall furnish and maintain an adequate supply of air conditioning/ heating spare parts to provide the level of maintenance specified in a timely manner. Heating and air conditioning units covered by these specifications are listed in Appendix! enter unit listing appendix!

PERIODIC PREVENTIVE MAINTENANCE. The contractor shall perform maintenance inspections, scheduled in the work load program on the HVAC systems listed in Appendix !list appropriate Appendix !. These systems shall be maintained by the contractor to standards that will insure the systems operate at their design capacity for their design life expectancy, free from defects that could effect their continued safe operation. Fans,coils and burners shall be in clean and in proper adjustment. Controls and control devices shall be properly adjusted and in good operating condition". Appendix C provides a check list for PM inspection as well as a preventive maintenance report format for HVAC systems.

SPECIFICATION ANALYSIS

Work Schedules- This schedule demonstrates the contractors execution plan for the continuing work such as janitorial, and grounds maintenance. The level of detail in this report and its completeness provide a measure of the contractor's ability to productively plan his work. His ability to keep to this schedule provides a measure of the contractors reliability, and supervisory control over his work force.

Work Programs- Both annual and monthly work load program reports will be submitted to enable the Maintenance Officer to identify areas or trades that require more emphasis as well as providing a data base to project the end BMAR report.

Annual Inspection Reports- These reports will provide a basis for all programmed work. The Maintenance Officer will be able to review these documents and prepare long range plans. The actual preparation of these plans should be done by maintenance staff personnel as there are governmental decisions that must be made. These long range plans if based on 100% inspection should provide valuable budgeting information for future years. As well as developing project

programs for the next fiscal year.

Preventive Maintenance Inspection Reports - These reports provide the Maintenance officer with an indicator of what the current condition of the facility or equipment. Additionally the reports set a standard for the contractor to follow. The inspection reports should use the specified format and be conducted in accordance with the HVAC and PM standards specifications. The quality of these reports reflects the level of planning ability of the contractor.

Cost Accounting Reports - These reports will permit the aggregation of maintenance money expenditures in to the Marine Corps Cost Accounting System. The accounting system will then be used to generate budget submissions as well as required reports to higher headquarters.

Facility History files- These files are to be maintained by the contractor on each facility. The files contain all documentation for the condition of, and work applied to the facility. By requiring this file to be maintained the maintenance manager can get a feel for the reliability of the contractors work.

As these reports, or information contained in these

reports, is currently being used in the Maintenance process, this should not be a new requirement for staff personnel.

Inspection Report Format

****
ANNUAL INSPECTION REPORT
DETAILED DEFICIENCY LISTING
****

Facility no.____

Inspector ____
****

DESCRIPTION OF DEFICIENCY REQUIRING CORRECTION	CRAFT	ESTIMATED COST			
		LABOR		mat'l or Const Cost	Total Cost
		Hrs	Cost		

CONTRACTOR'S MAINTENANCE COST REPORT

INSTRUCTIONS

1. The contractor will provide a monthly cost report to the service contracting office not later than the fifth (5th) working day of the month following the period reported. The report will be in the format described in attachment 1 to this Appendix.

2. The grand total of expenditures reported on all cost reports must equal the total of the contractor's invoice for the same time period.

3. Descriptions of the individual line items together with an explanation of the work units are contained in attachment 2 to this Appendix.

CONTRACTOR'S MAINTENANCE COST REPORT

FOR THE MON OF _____________19_____

COST CODE	DESCRIPTION	LABOR	MATLS	TOTAL
71JO	Repairs to community Support Facilities	$	$	$
	TOTAL OPERATIONS	------	-----	------

HEATING AND AIR CONDITIONING

PREVENTIVE MAINTENANCE FORMAT

****

Note to Specification Writer: Modify this list as necessary to specify the equipment to recieve PM inspection.

****

Facility:___________________ Date____________

Heating___________ A/C__________ Craftsman:______

1. Lubrication:

Fan Shaft Yes______ No_____ Sealed Bearings______

Fan Motor Yes______ No_____ Sealed Bearings______

Condenser

Fan Motor Yes______ No____ Sealed Bearings______

2. Electrical Loads: (Record after 30 minutes of operation).

Air handling units motor ---------------Amps

Condensor fan motor _______________Amps

Compressor motor _______________Amps

Running volts at compressor _______________Amps

3. Air Filters:

Changes __________ Yes_____ No_______

Cleaned __________ Yes_____ No_______

4. Belts:

In good condition

with no vibrations Yes______ No_______

Belt tension can

be depress about ___________inches.

5. Areas Cleaned:

Air handling room Yes_______ No______

Air handling unit Yes_______ No______

Compressor condensor

unit and frame Yes_______ No______

Condensate drip

pipe flushed out Yes_______ No______

Condensate drip pan Yes_______ No______

Condensor coil Yes_______ No______

EVAPORATE coil differential pressure reading_____inches.

6. Insulation:

Is direct vapor barrier and insulations in good condition

w/no torn or wet spots? Yes_____ No______.

Duct Air Leaks Yes________ No________

Dust vapor barrier

satisfactory Yes________ No________

7. Electrical wiring:

Insulation good? Yes________ No________

Does any wiring need

repairing? Yes________ No________

8. Temperature Controls:

Operating Satisfactorily Yes_______ No________

9. Refrigerent Data: as appropriate.

10. Gas Furnances: as appropriate.

11. Oil Furnance: as appropriate.

12. Dampers registers: as appropriate.

13. Smoke detectors: (If applicable).

APPENDIX E

SAMPLE SIZE DETERMINATION

APPENDIX E

Sample Size Determination

In this situation neither the feasible range of the output nor the values for the standard deviation are known with any certainty. The objective of this study is to obtain a 90% probability that the true values for the report elements are within one-half standard deviation of the of the sample mean values. The sample size required (assuming a normal didtribution) to meet this objective is given in the calculation below.

$$\text{Sample Size} = \frac{(1.65 \times \sigma)^{**}2}{(\sigma/2)^{**}2}$$

$$= \frac{(1.65^{**}2)\times(2^{**}2)\times \sigma^{**}2}{\sigma^{**}2}$$

= 10.89 say 11

[Shannon,1975,p.188]

A sample size of 11 will be used for these experiments. The value for Z for 1-(α /2) is 1.65.

APPENDIX F

BASELINE EXPERIMENT FIGURES

Appendix F
Baseline Experiment Figures

****

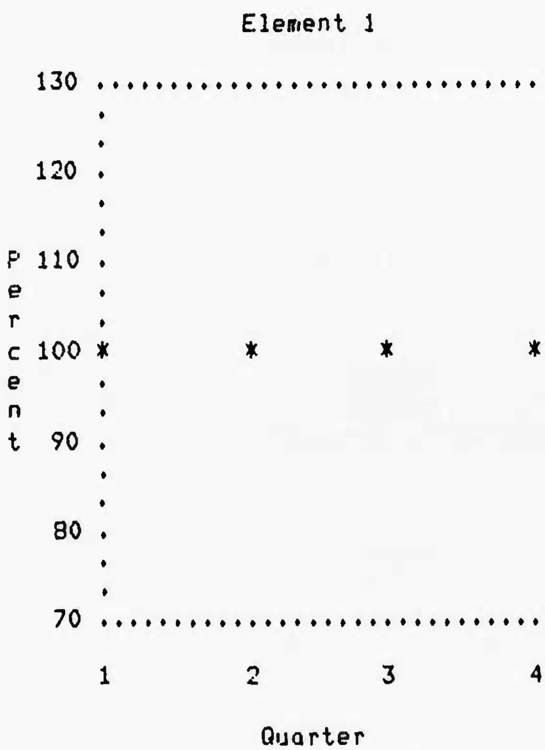
Camp Samuel Nicholas
(small)

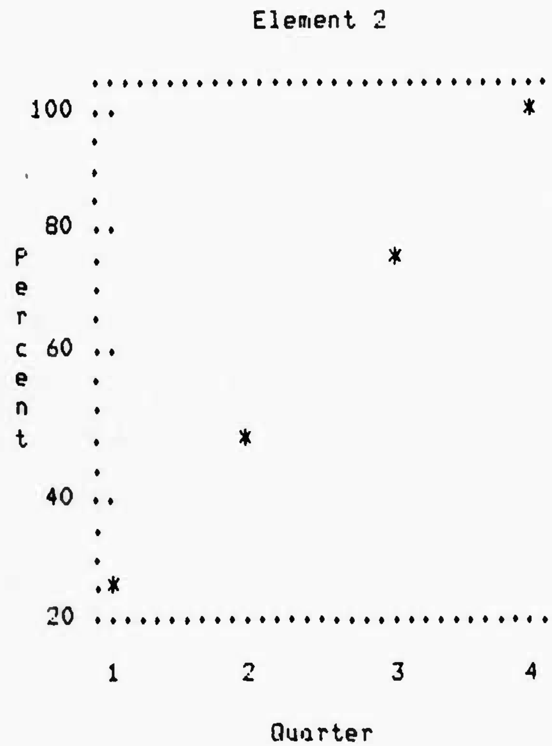
Effectiveness Report No. 6

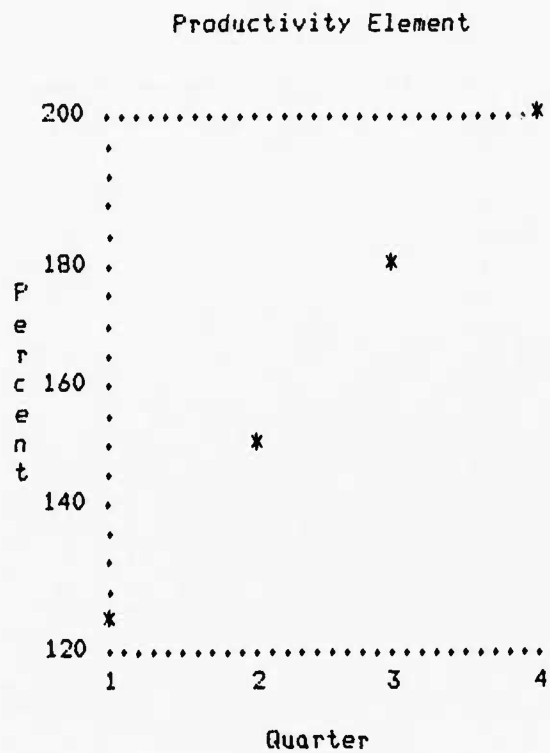
Element	First Qtr	Second Qtr	Third Qtr	Fourth Qtr
	Productivity Factors			
1	100.00	100.00	100.00	100.00
2	24.63	50.78	75.99	100.00
Sum	124.63	150.78	175.99	200.00
	Planning Factors			
3	22.42	47.05	70.40	93.30
4	9.09	9.09	9.09	12.73
5	74.55	74.55	80.00	72.73
Sum	106.05	130.69	159.49	178.76
	Reliability Factors			
6	100.00	100.00	100.00	100.00
7	24.96	50.28	74.99	100.00
Sum	124.96	150.28	174.99	200.00
	Initiation Factors			
8	.00	76.10	78.72	68.29
Sum	.00	76.10	78.72	68.29
Rating	104.01	138.99	155.71	186.62

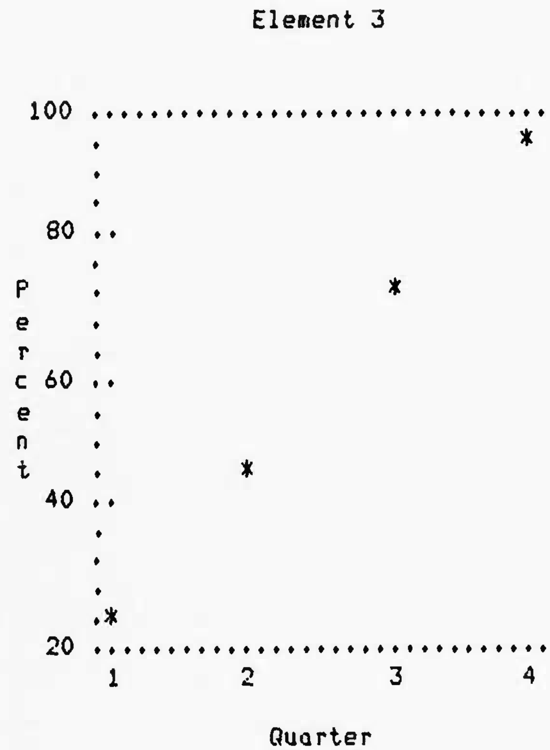
****

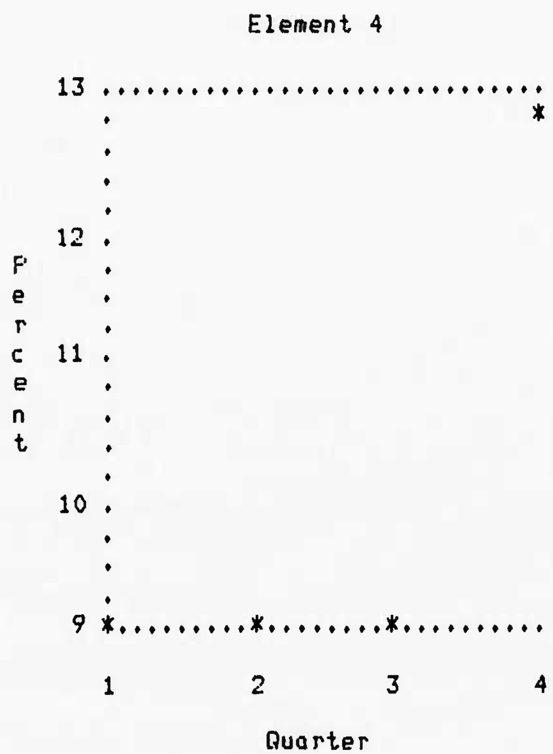
The following graphs represent the baseline activity in an ideal operating state.

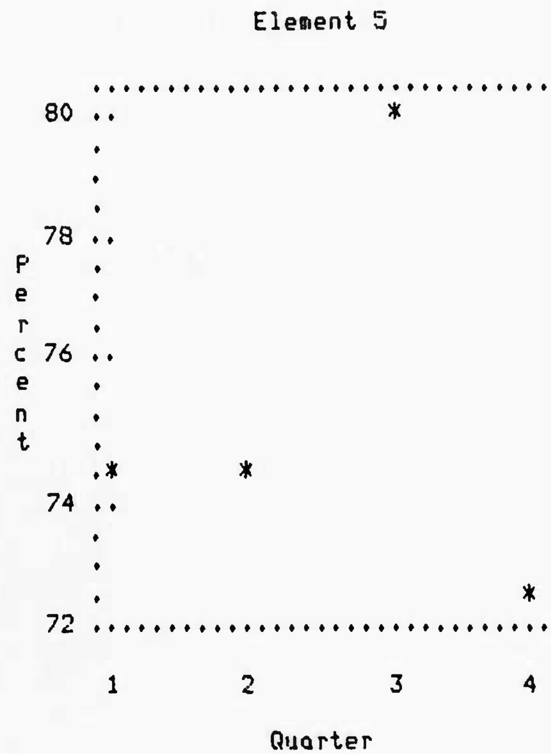


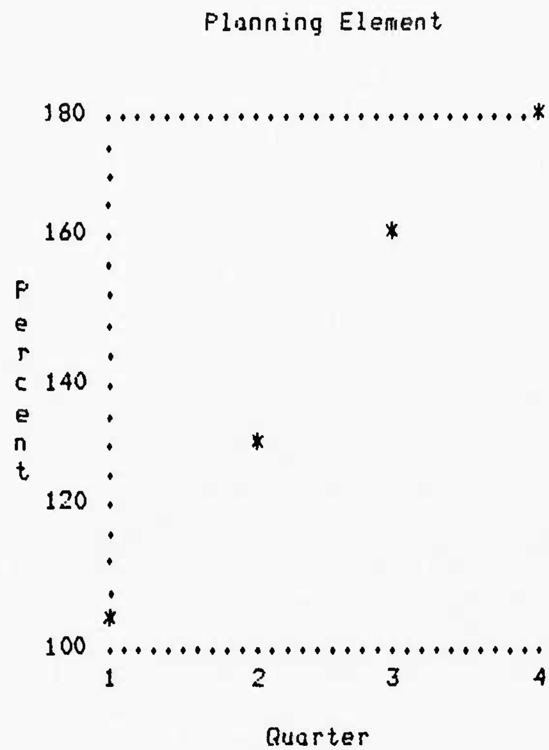


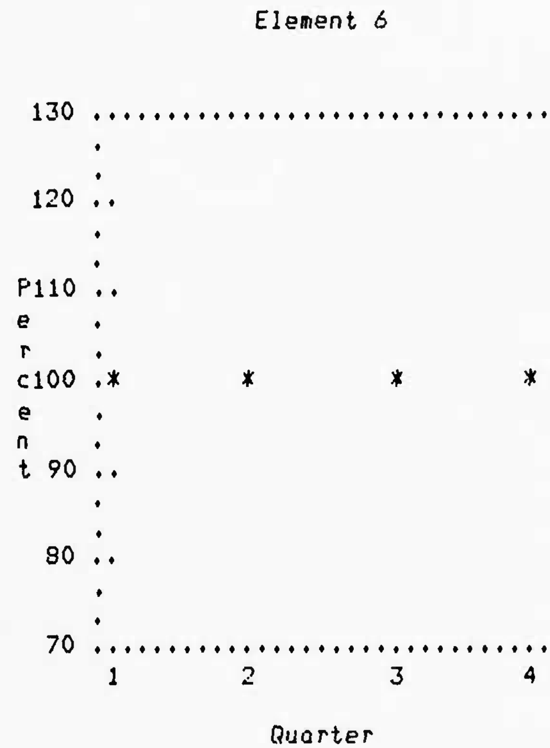

Productivity Element
200
180
160
140
120
Percent
1
2
3
4
Quarter

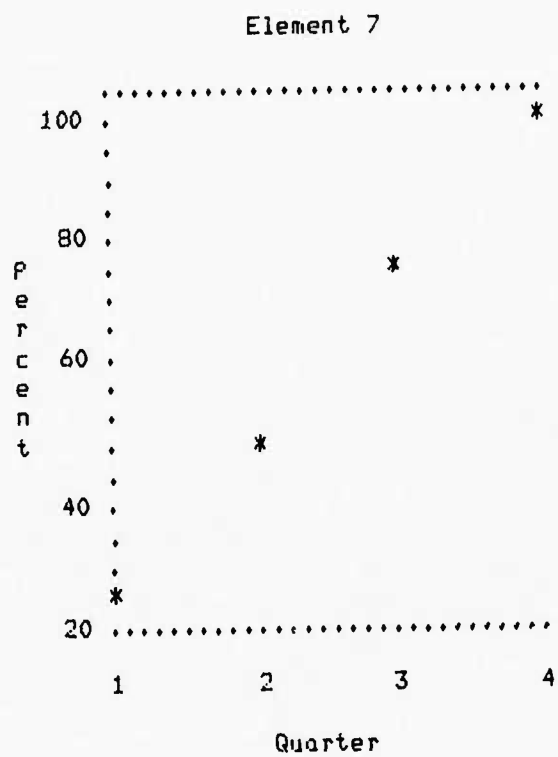

Element 3
100
80
60
40
20
Percent
1
2
3
4
Quarter

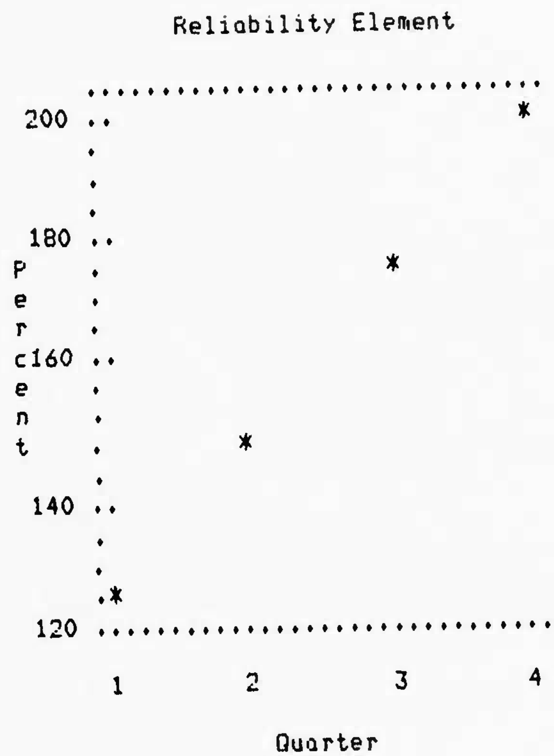

Element 4
13
12
11
10
9
Percent
1
2
3
4
Quarter


Element 5
80
78
76
74
72
Percent
1
2
3
4
Quarter

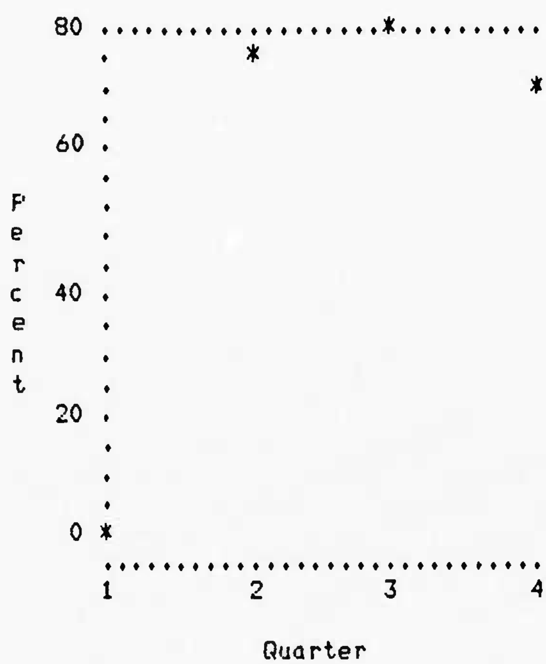

Planning Element
180
160
140
120
100
Percent
1
2
3
4
Quarter


Element 6
130
120
110
100
90
80
70
Percent
1
2
3
4
Quarter

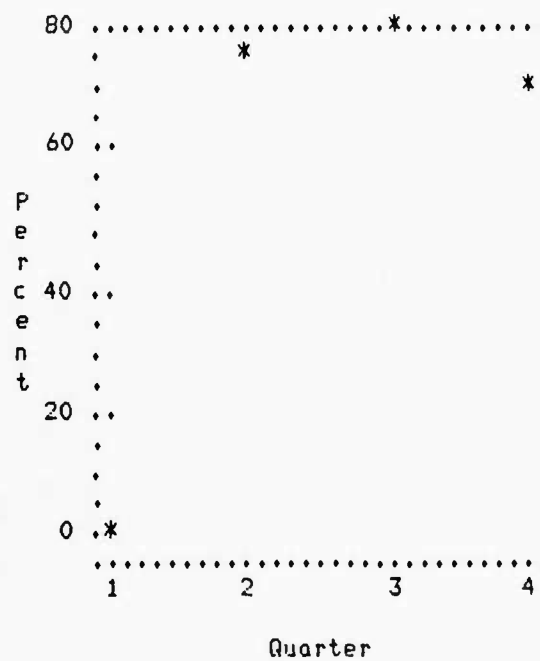

Element 7
100
80
60
40
20
Percent
1
2
3
4
Quarter

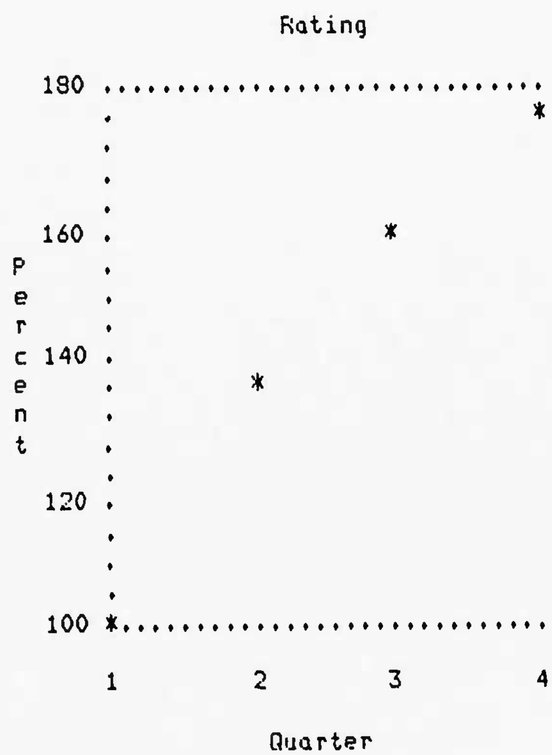

Reliability Element
200
180
160
140
120
Percent
1
2
3
4
Quarter

Element 8



Initiation Element





Rating
180
160
140
120
100
Percent
1
2
3
4
Quarter

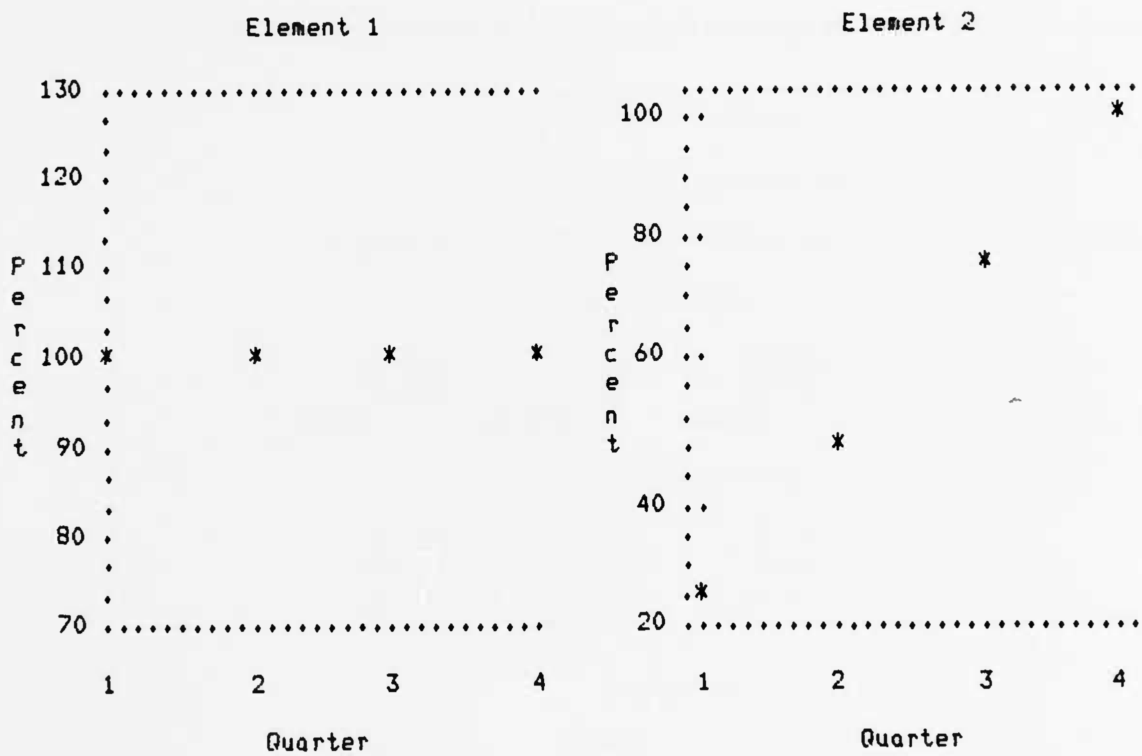
****

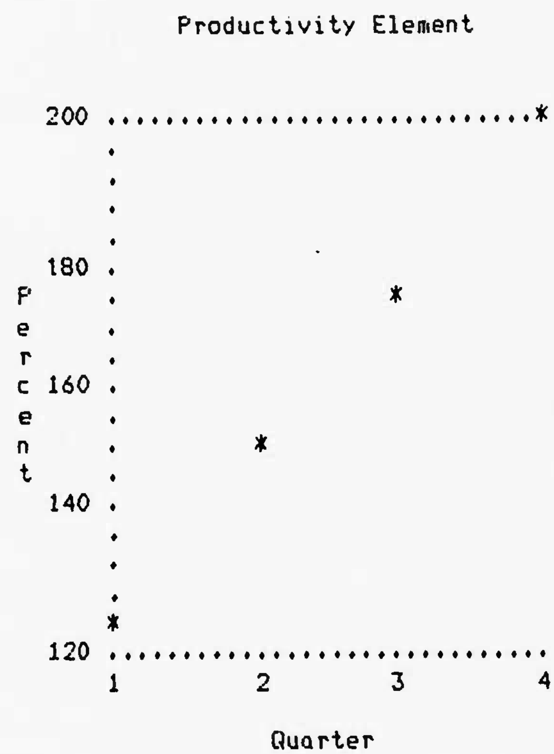
Camp William W. Burrows
(medium)

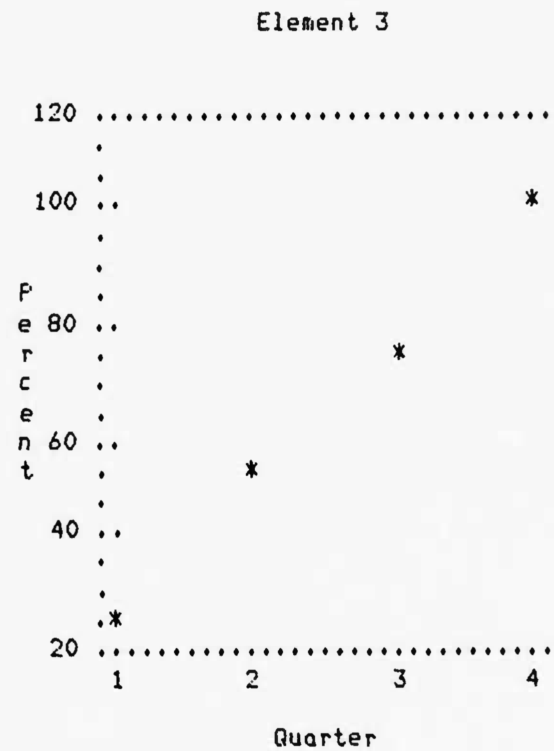
Effectiveness Report No. 6

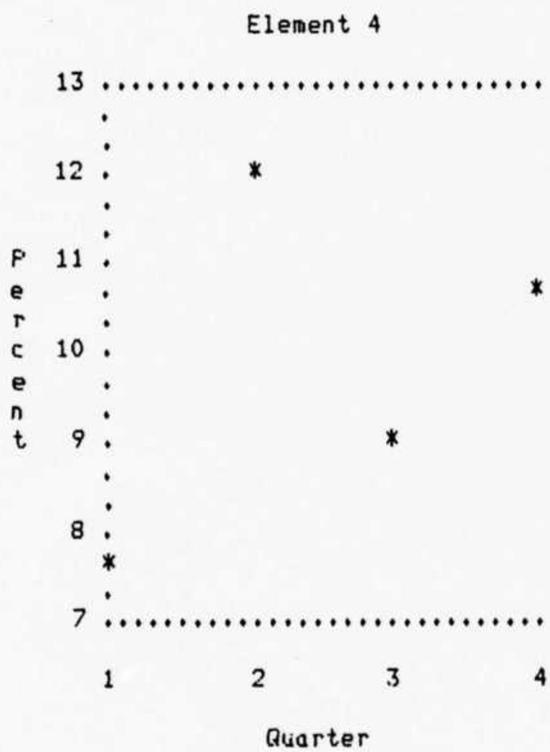
Element	First Qtr	Second Qtr	Third Qtr	Fourth Qtr
		Productivity Factors		
1	100.00	100.00	100.00	100.00
2	25.65	50.00	75.20	100.00
Sum	125.65	150.00	175.20	200.00
		Planning Factors		
3	24.75	49.69	74.81	100.12
4	7.79	12.01	9.09	10.88
5	77.76	73.70	75.16	76.62
Sum	110.31	135.41	159.07	187.62
		Reliability Factors		
6	100.00	100.00	100.00	100.00
7	25.16	50.06	75.02	100.00
Sum	125.16	150.06	175.02	200.00
		Initiation Factors		
8	.00	74.36	73.81	78.34
Sum	.00	74.36	73.81	78.34
Rating	106.94	134.27	159.51	181.67

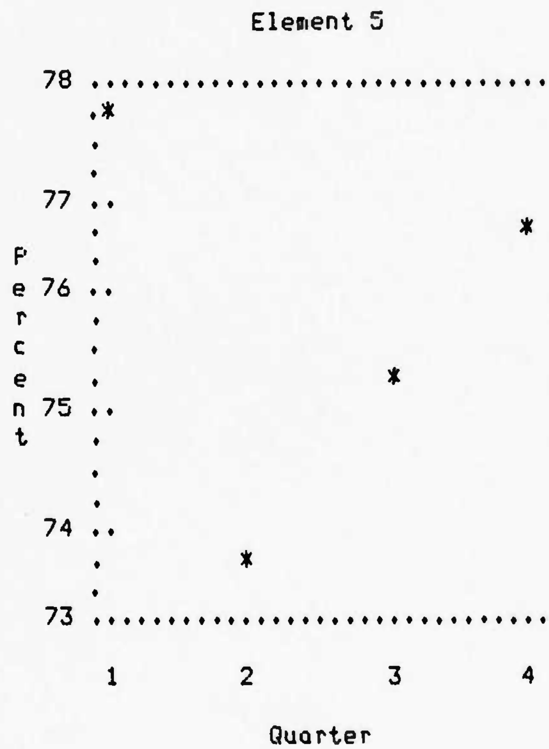
****


Element 1
130
120
110
100
90
80
70
Percent
1
2
3
4
Quarter
Element 2
100
80
60
40
20
Percent
1
2
3
4
Quarter

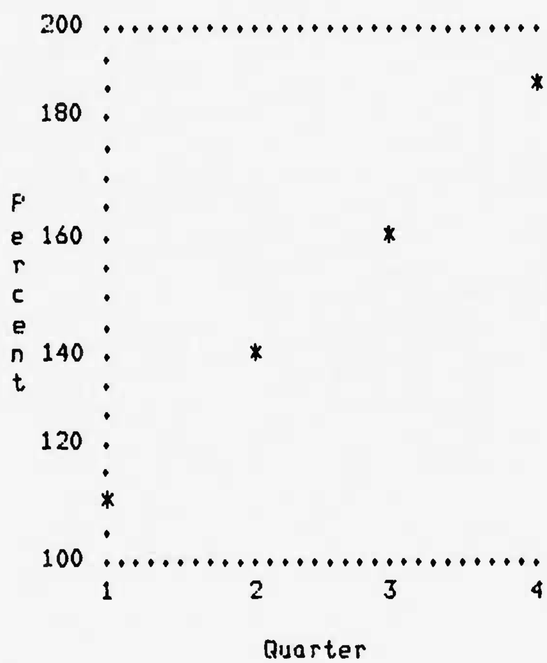

Productivity Element
200
180
160
140
120
Percent
1
2
3
4
Quarter


Element 3
120
100
80
60
40
20
Percent
1
2
3
4
Quarter

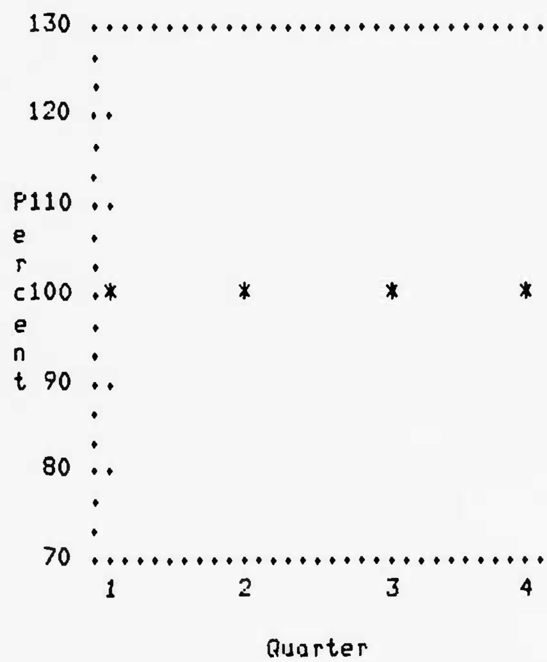

Element 4
Percent
13
12
11
10
9
8
7
1
2
3
4
Quarter

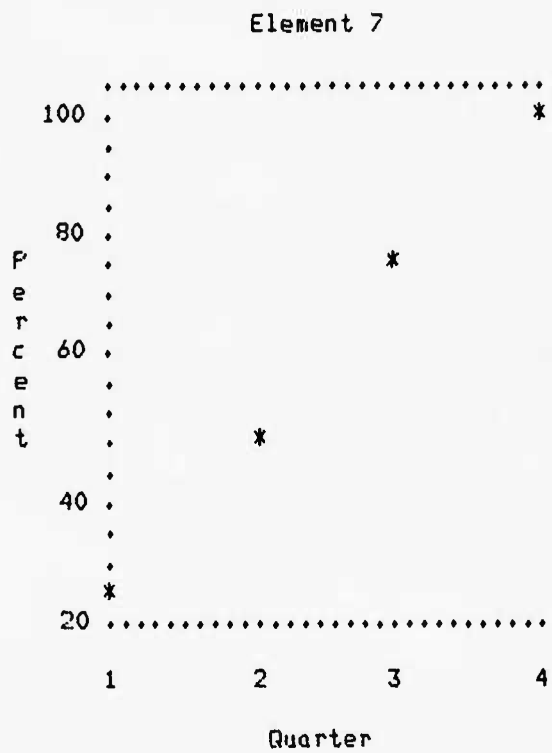

Element 5
Percent
78
77
76
75
74
73
1
2
3
4
Quarter

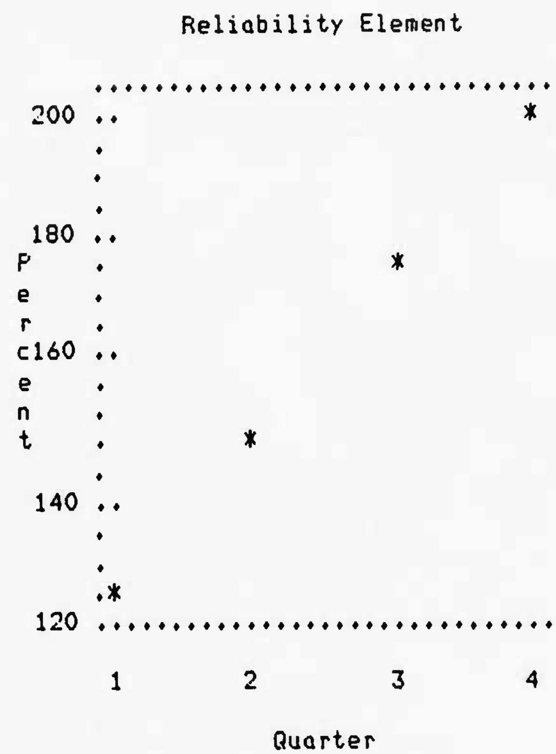
Planning Element



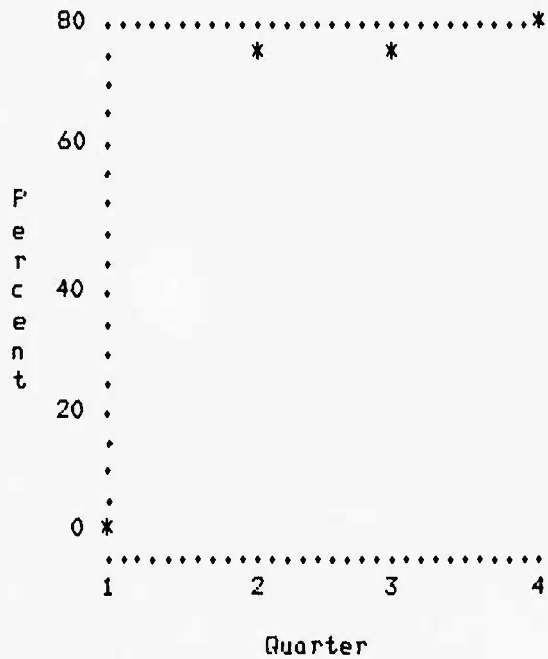
Element 6



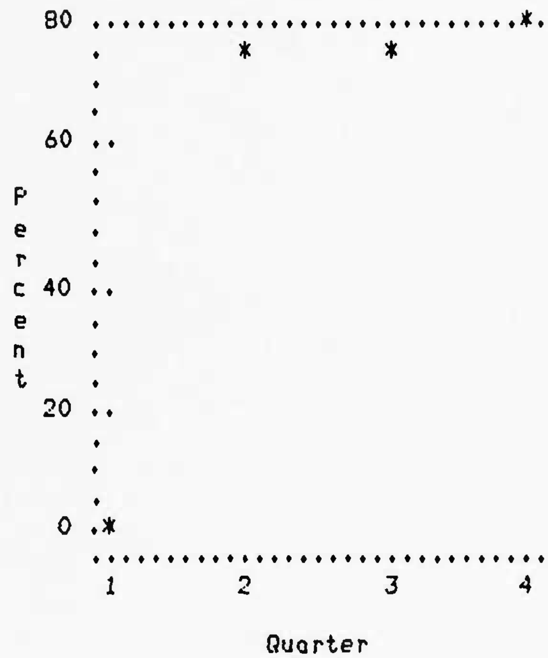

Element 7
100
80
60
40
20
Percent
1
2
3
4
Quarter

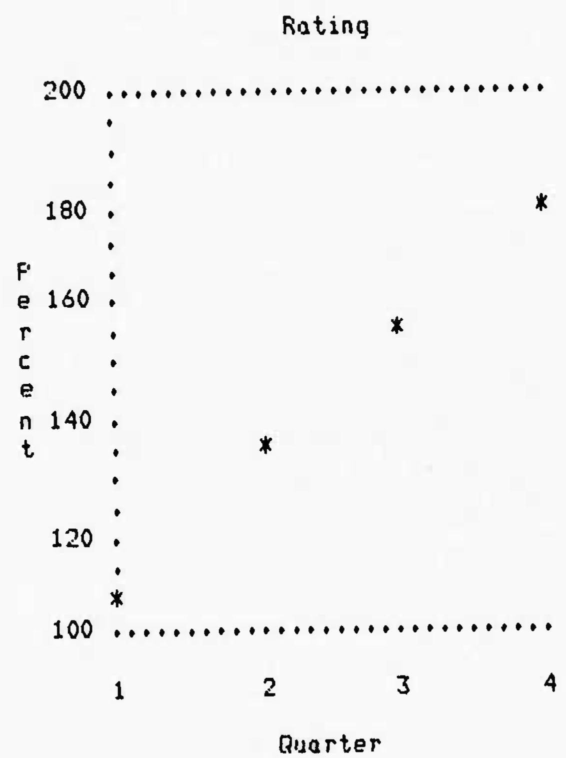

Reliability Element
200
180
160
140
120
Percent
1
2
3
4
Quarter

Element 8



Initiation Element




Rating
200
180
160
140
120
100
Percent
1
2
3
4
Quarter

The following information represents the results of the baseline experiment for the largest base.

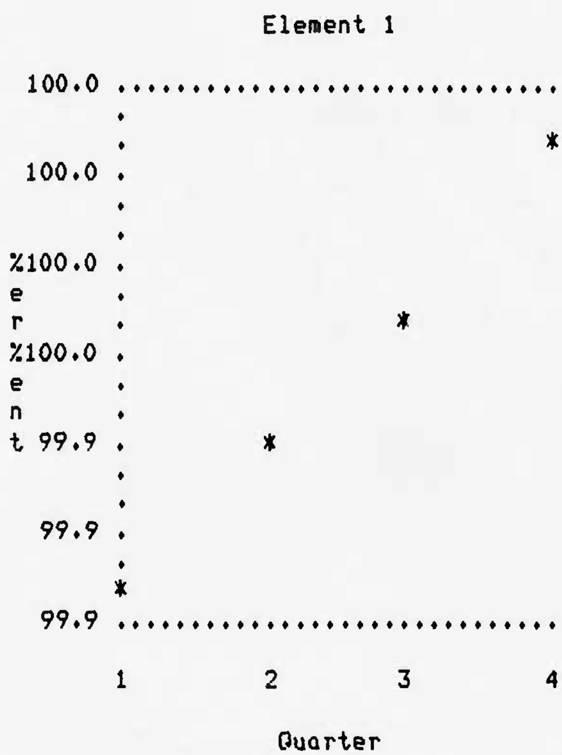
****

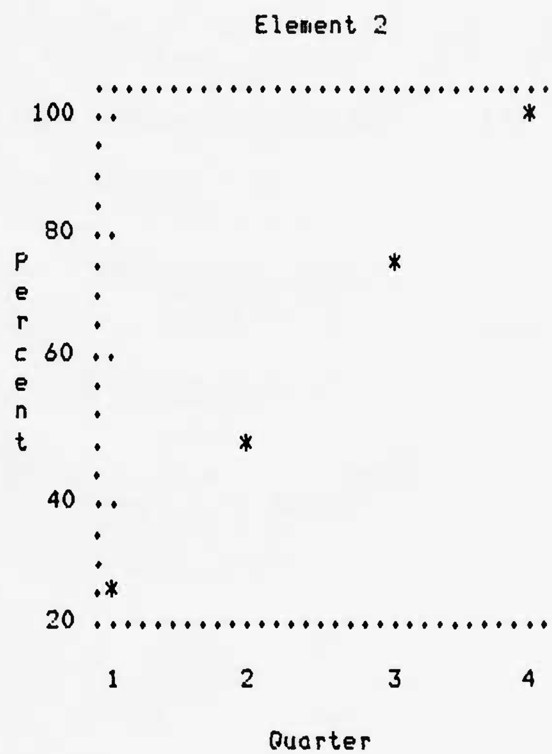
Camp Presly N. OBannon
(large)

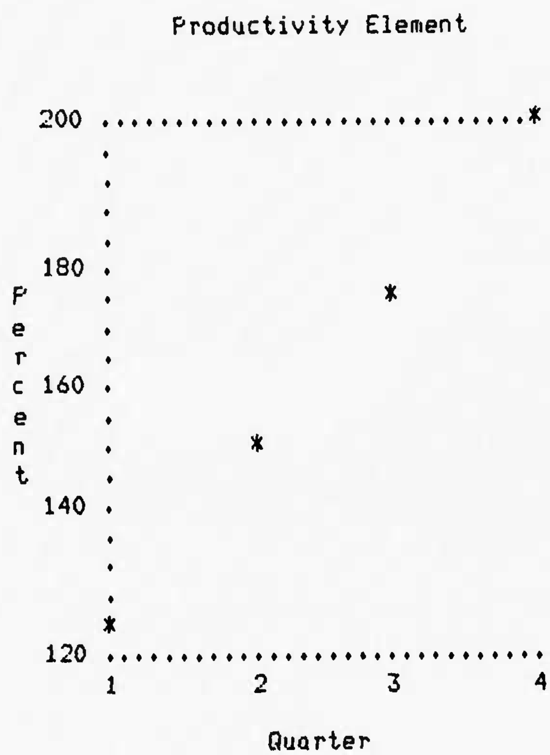
Effectiveness Report No. 6

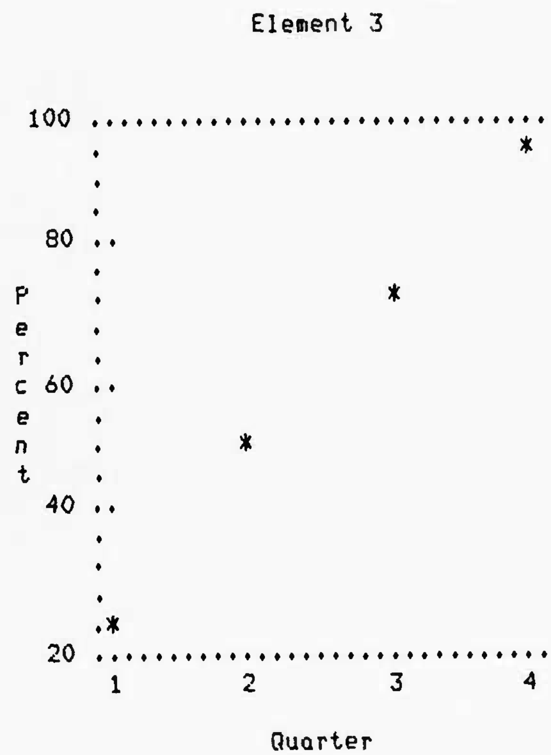
Element	First Qtr	Second Qtr	Third Qtr	Fourth Qtr
	Productivity Factors			
1	99.91	99.94	99.97	100.01
2	24.81	49.71	74.84	99.96
Sum	124.73	149.66	174.81	199.97
	Planning Factors			
3	23.97	47.99	71.95	95.91
4	9.97	10.19	10.32	10.57
5	74.33	74.59	74.90	75.21
Sum	108.27	132.78	157.18	181.69
	Reliability Factors			
6	99.89	99.98	99.94	100.07
7	24.97	49.97	74.92	99.97
Sum	124.86	149.95	174.85	200.04
	Initiation Factors			
8	.00	74.53	74.46	74.85
Sum	.00	74.53	74.46	74.85
Rating	104.60	134.75	157.59	179.23

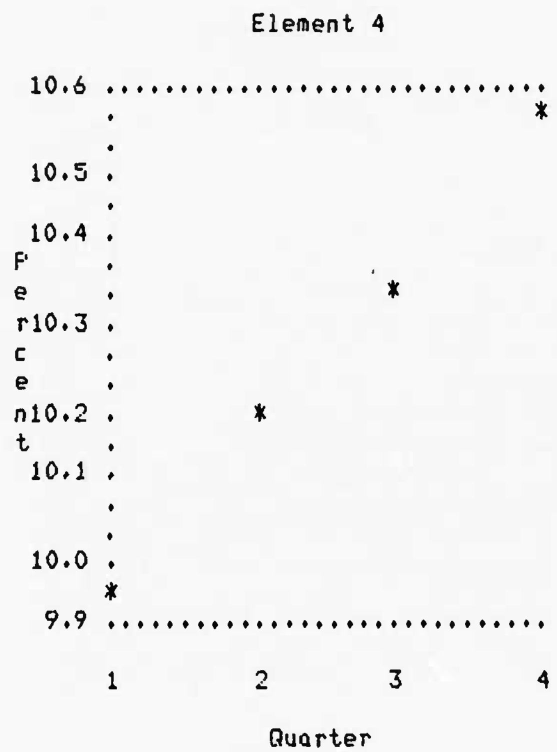
****

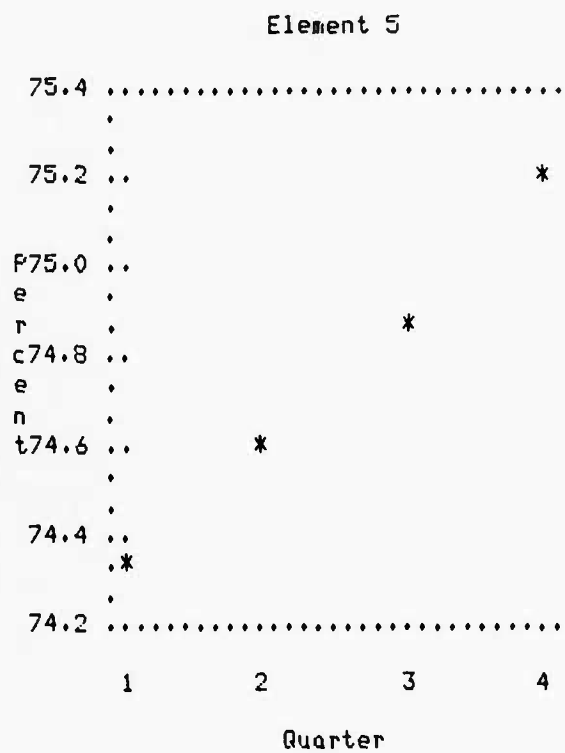

Element 1
100.0
100.0
%100.0
%100.0
99.9
99.9
99.9
Percent
1
2
3
4
Quarter

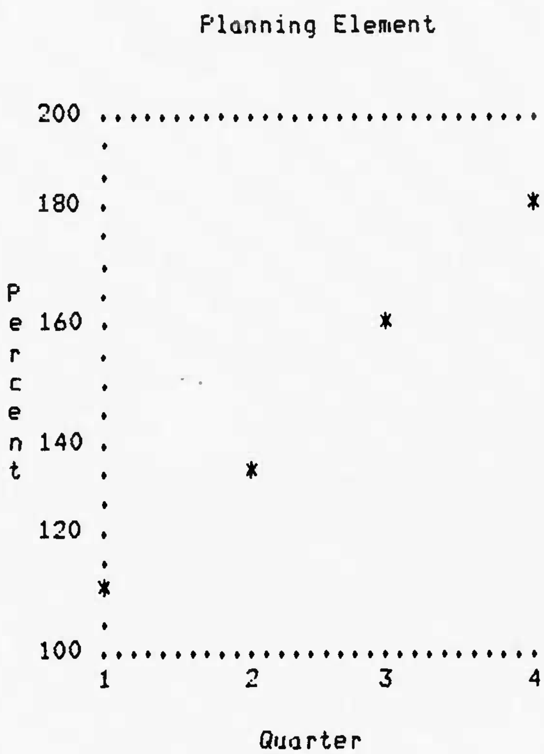

Element 2
100
80
60
40
20
Percent
1
2
3
4
Quarter

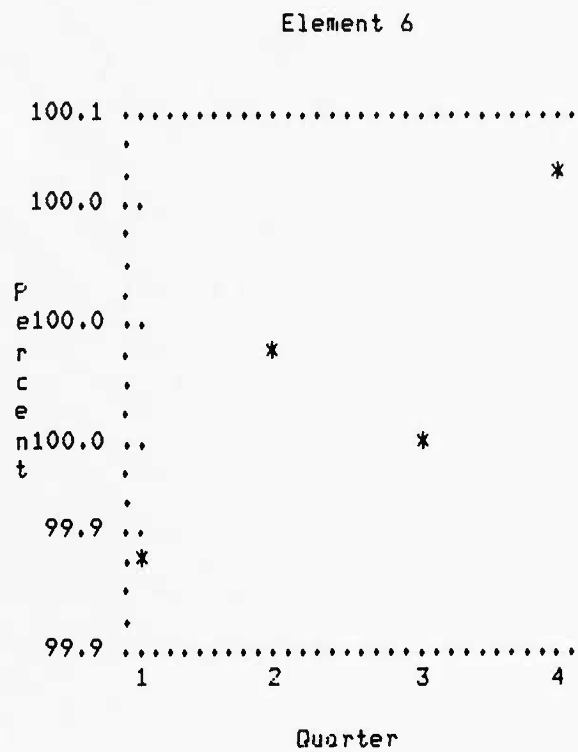

Productivity Element
200
180
160
140
120
Percent
1
2
3
4
Quarter

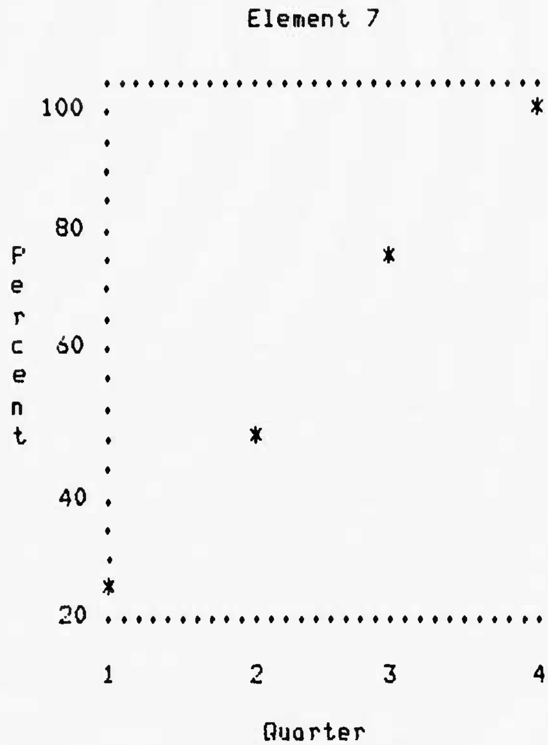

Element 3
100
80
60
40
20
Percent
1
2
3
4
Quarter

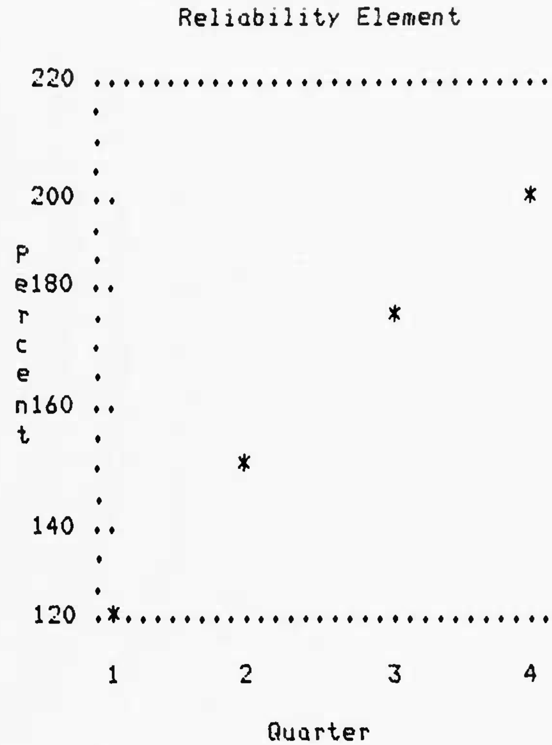

Element 4
10.6
10.5
10.4
Percent
10.3
10.2
10.1
10.0
9.9
1
2
3
4
Quarter

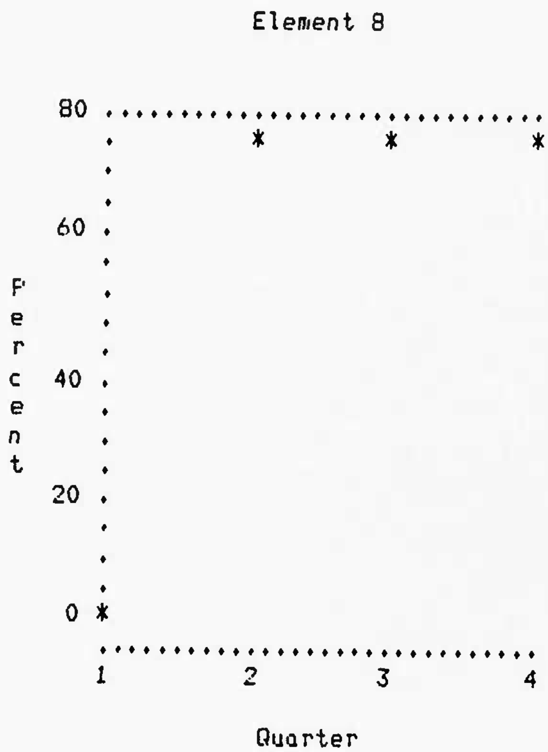

Element 5
75.4
75.2
Percent
75.0
74.8
74.6
74.4
74.2
1
2
3
4
Quarter

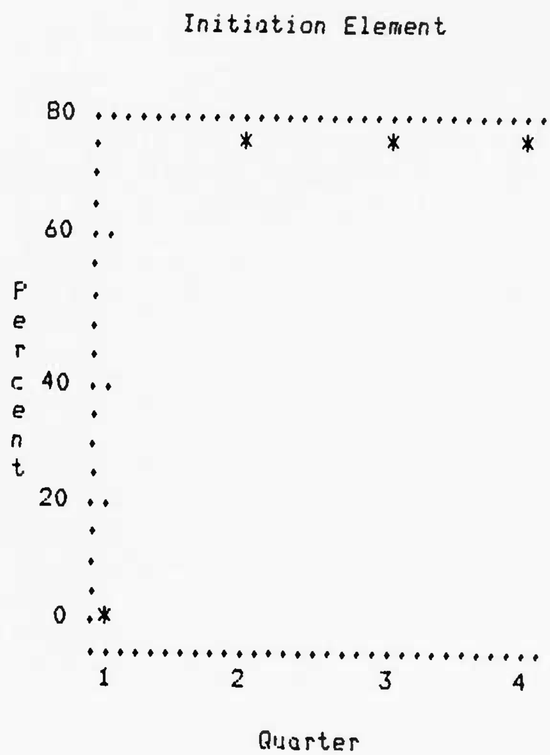

Planning Element
200
180
160
140
120
100
Percent
1
2
3
4
Quarter

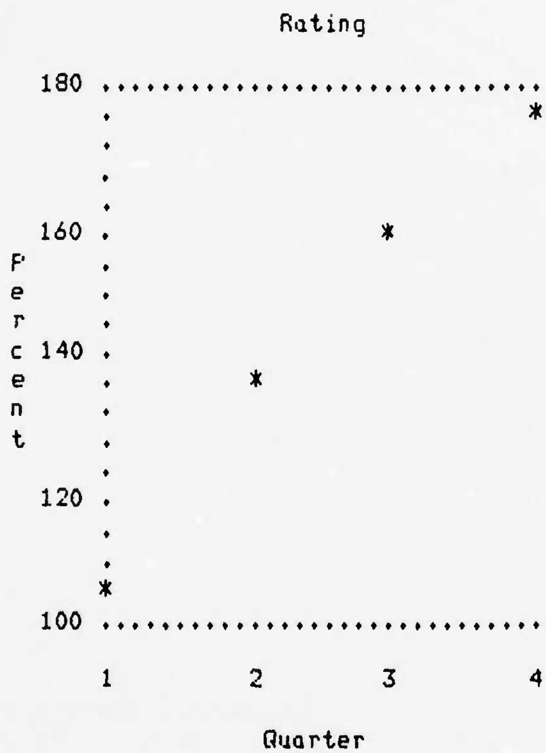

Element 6
100.1
100.0
100.0
100.0
99.9
99.9
Percent
1
2
3
4
Quarter


Element 7
100
80
Percent
60
40
20
1
2
3
4
Quarter


Reliability Element
220
200
Percent
180
160
140
120
1
2
3
4
Quarter


Element 8
80
60
Percent
40
20
0
1
2
3
4
Quarter


Initiation Element
80
60
Percent
40
20
0
1
2
3
4
Quarter


Rating
180
160
140
120
100
Percent
1
2
3
4
Quarter

APPENDIX G

MAN-HOUR AVAILABILITY EXPERIMENT FIGURES

APPENDIX G
Man-Hour Availability Experiment Results

****

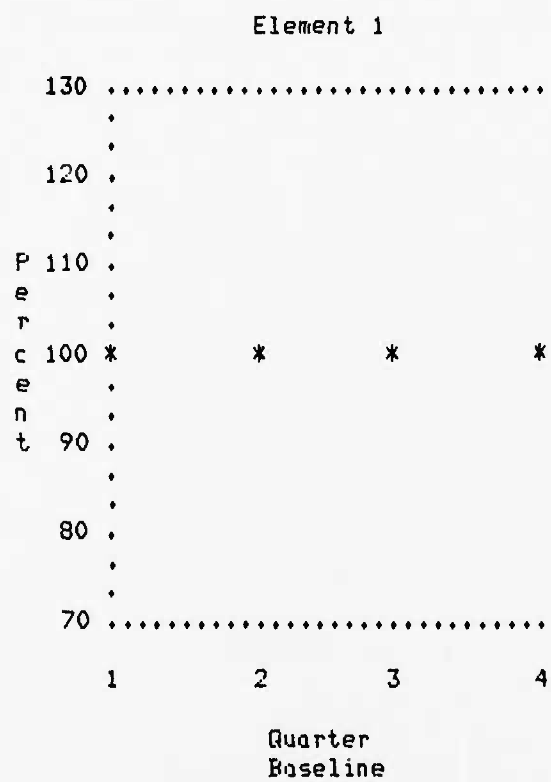
Camp Samuel Nicholas
(small)

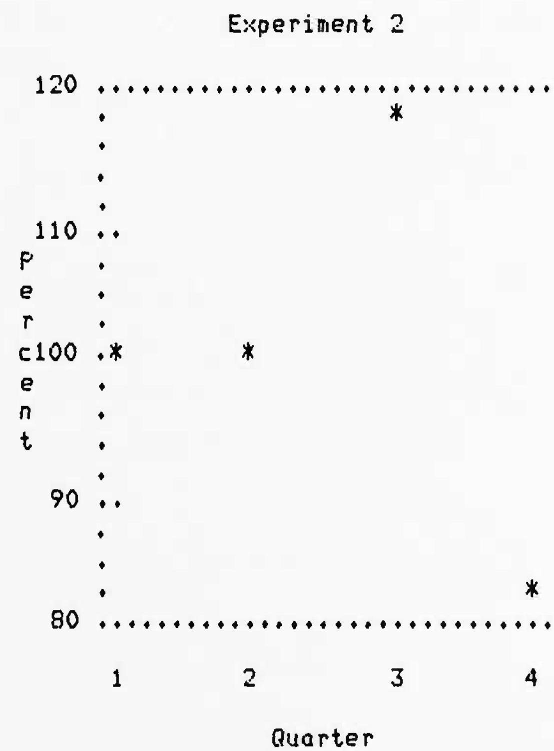
Effectiveness Report No. 6

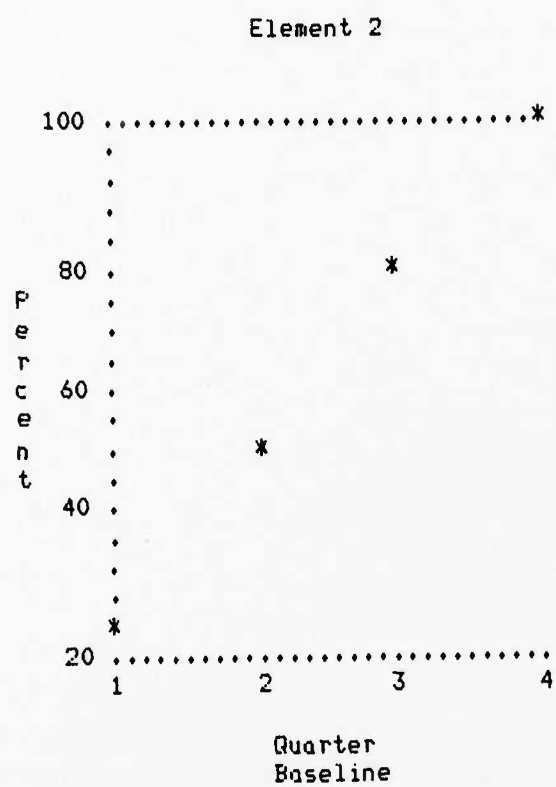
Element	First Qtr	Second Qtr	Third Qtr	Fourth Qtr
		Productivity Factors		
1	100.00	100.00	117.85	82.46
2	24.63	50.78	80.35	100.00
Sum	124.63	150.78	198.20	182.46
		Planning Factors		
3	22.42	47.05	70.40	93.30
4	9.09	9.09	9.09	12.73
5	74.55	74.55	80.00	72.73
Sum	106.05	130.69	159.49	178.76
		Reliability Factors		
6	100.00	100.00	117.58	102.52
7	24.96	50.28	79.34	104.99
Sum	124.96	150.28	196.92	207.51
		Initiation Factors		
8	.00	76.10	122.86	14.12
Sum	.00	76.10	122.86	14.12
Rating	104.01	138.99	180.22	171.07

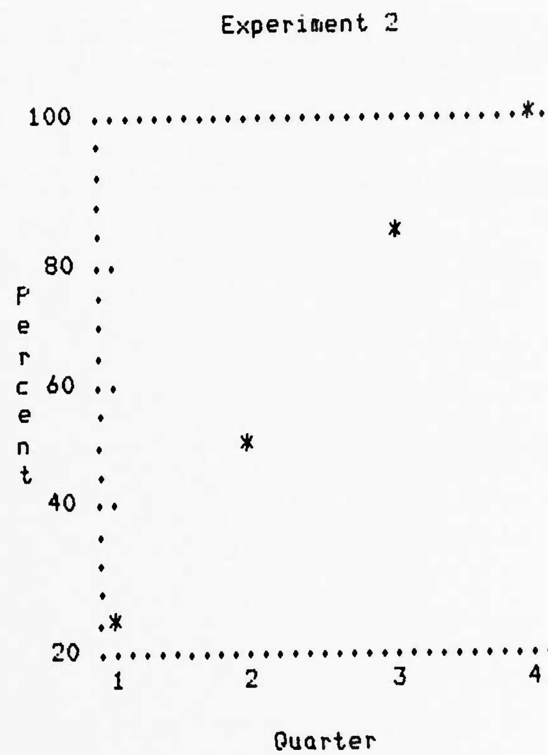
****

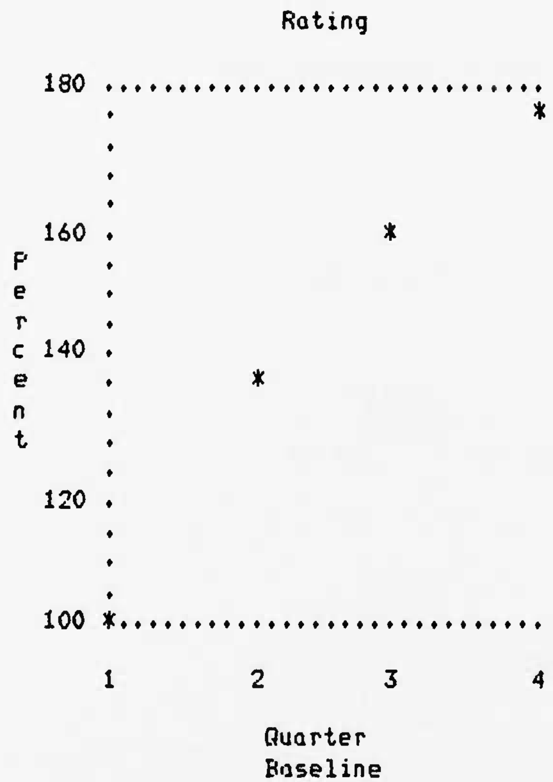
The following graphs represent the Man-Hour availability Experiment results for the smallest base.

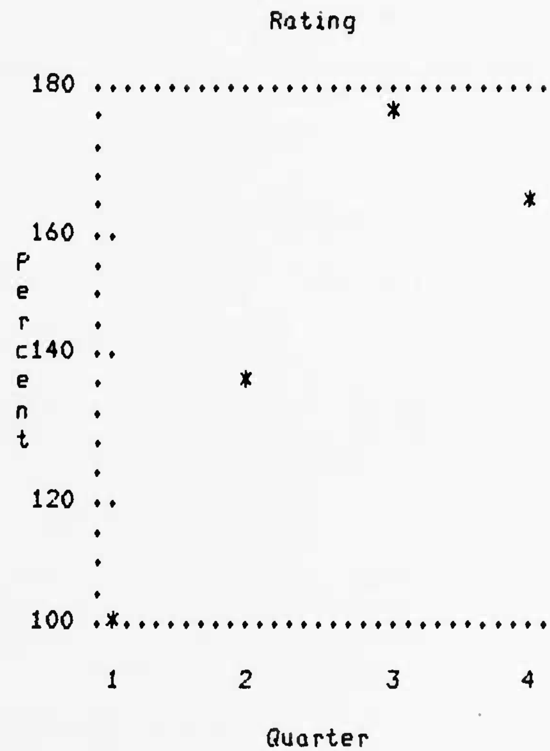





Element 2
100
80
60
40
20
Percent
1
2
3
4
Quarter
Baseline


Experiment 2
100
80
60
40
20
Percent
1
2
3
4
Quarter


Rating
180
160
140
120
100
Percent
1
2
3
4
Quarter
Baseline


Rating
180
160
140
120
100
Percent
1
2
3
4
Quarter

The following information represents the results of the Man-hour availability experiments for the medium size base.

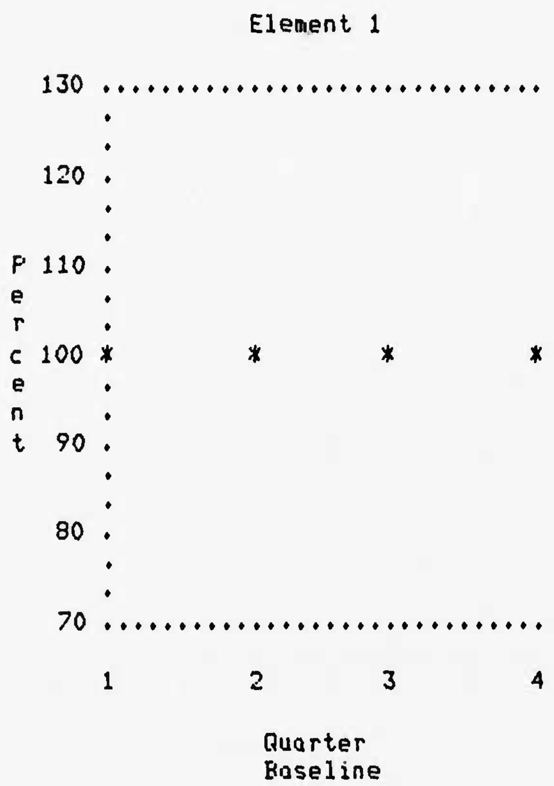
****

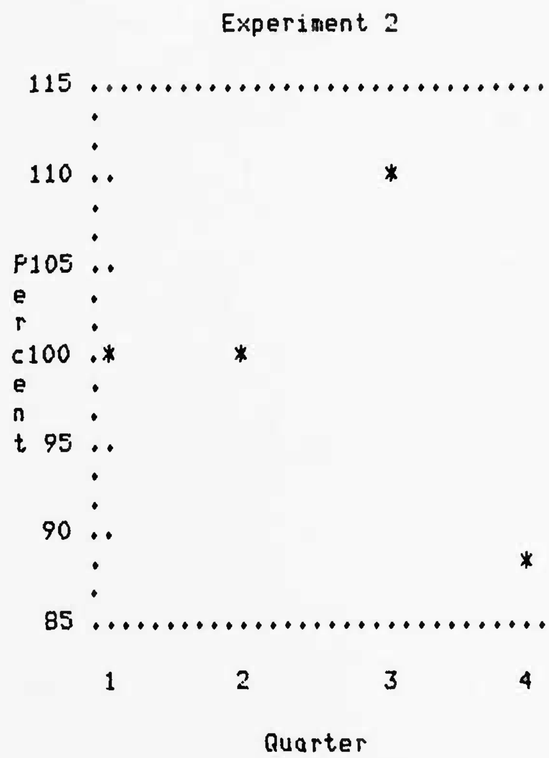
Camp William W. Burrows
(medium)

Effectiveness Report No. 6

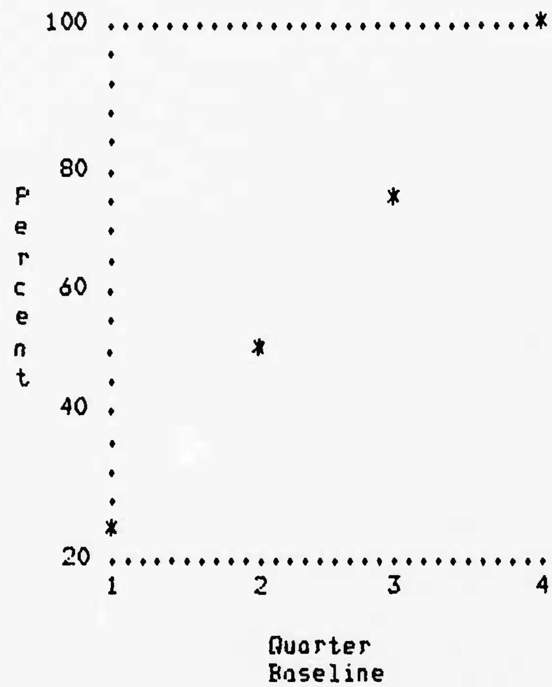
Element	First Qtr	Second Qtr	Third Qtr	Fourth Qtr
	Productivity Factors			
1	100.18	99.95	110.53	89.18
2	25.66	50.01	77.87	100.00
Sum	125.85	149.97	188.40	189.18
	Planning Factors			
3	34.75	69.69	104.81	140.12
4	7.81	12.01	9.09	10.88
5	77.72	73.70	75.16	76.62
Sum	120.28	155.41	189.07	227.62
	Reliability Factors			
6	100.19	100.03	109.96	100.44
7	25.17	50.09	77.54	102.65
Sum	125.36	150.12	187.50	203.08
	Initiation Factors			
8	.00	84.01	109.47	54.91
Sum	.00	84.01	109.47	54.91
Rating	109.44	140.57	177.55	186.23

****

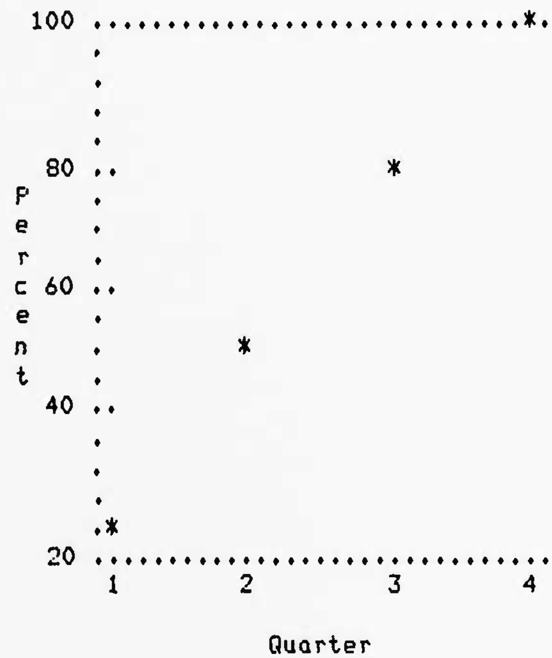

Element 1
130
120
110
100
90
80
70
Percent
1
2
3
4
Quarter
Baseline

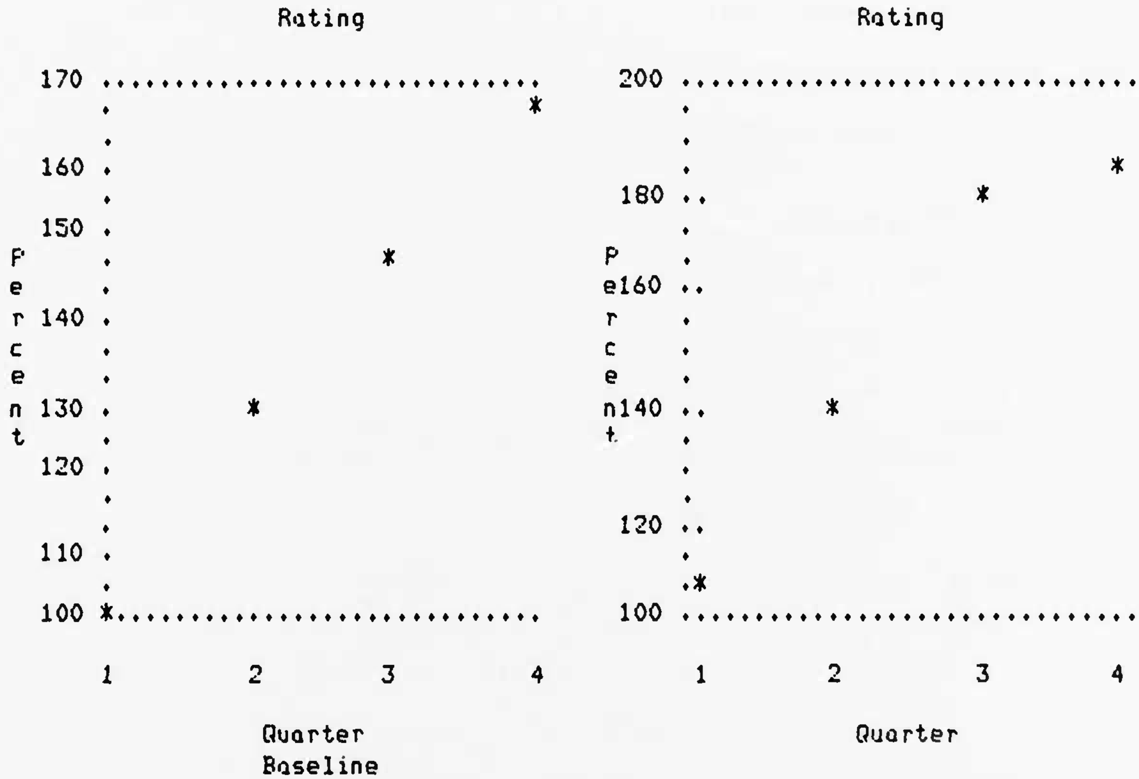

Experiment 2
115
110
105
100
95
90
85
Percent
1
2
3
4
Quarter

Element 2



Experiment 2




Rating
170
160
150
140
130
120
110
100
Percent
1
2
3
4
Quarter
Baseline
Rating
200
180
160
140
120
100
Percent
1
2
3
4
Quarter

This information represents the results of the manhour availability experiment for the largest base.

****

Camp Presly N. OBannon
(large)

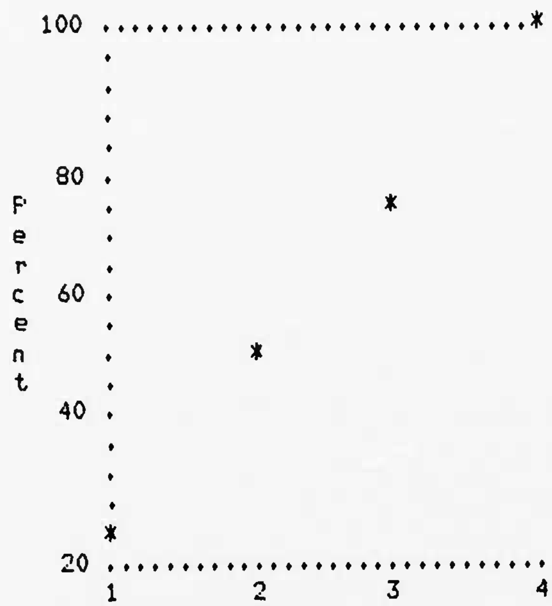
Effectiveness Report No. 6

Element	First Qtr	Second Qtr	Third Qtr	Fourth Qtr
	Productivity Factors			
1	99.88	99.95	100.06	100.11
2	24.81	49.71	74.86	100.00
Sum	124.69	149.66	174.92	200.11
	Planning Factors			
3	23.97	47.99	71.95	95.91
4	9.97	10.19	10.32	10.57
5	74.33	74.59	74.90	75.21
Sum	108.27	132.78	157.18	181.69
	Reliability Factors			
6	99.86	100.00	99.99	110.03
7	24.97	49.97	74.92	102.47
Sum	124.83	149.96	174.91	212.50
	Initiation Factors			
8	.00	74.61	74.60	87.29
Sum	.00	74.61	74.60	87.29
Rating	104.60	134.75	157.59	183.24

****

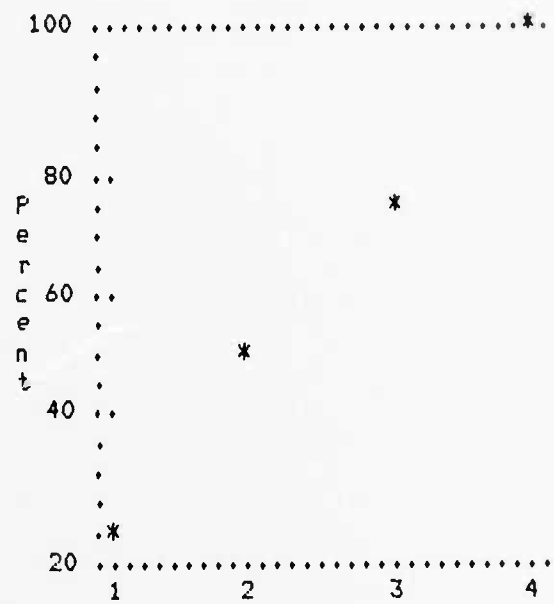
```
                 Element 1                                  Experiment 2

100.0 ..............................       100.2 ...............................
      .                                          .
      .                             *            .
100.0 .                                    100.1 ..                             *
      .                                          .
      .                                          .
P100.0.                                    P100.1 ..                    *
e     .                                    e     .
r     .                 *                  r     .
c100.0.                                    c100.0 ..
e     .                                    e     .
n     .                                    n     .
t99.9 .         *                          t100.0 ..        *
      .                                          .
      .                                          .
 99.9 .                                     99.9 ..
      .                                          .
      *                                          .*
 99.9 ..............................        99.9 ...............................

      1         2        3         4             1        2         3        4

               Quarter                                   Quarter
               Baseline
```

Element 2

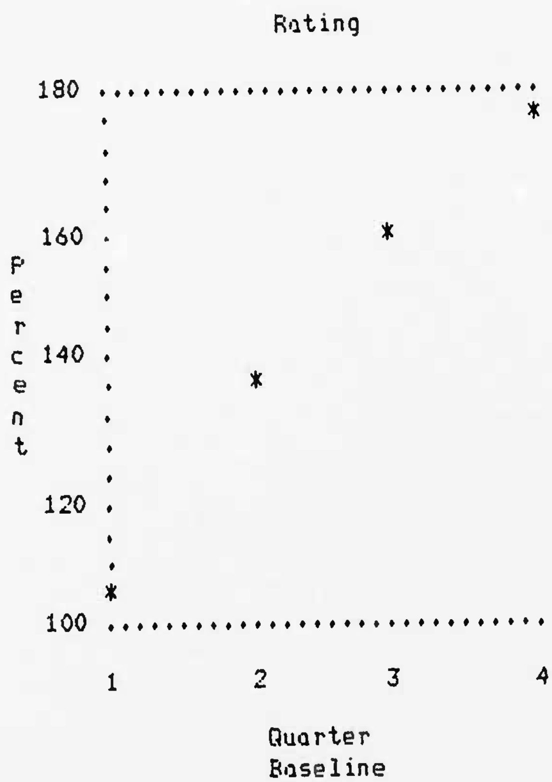


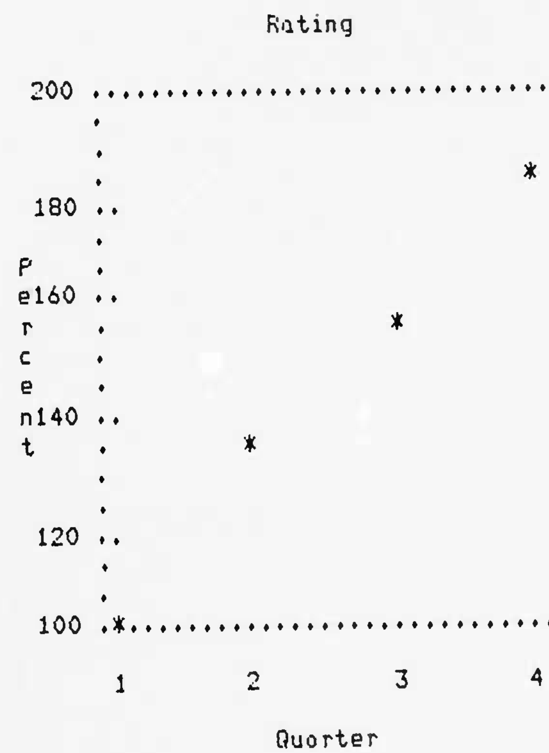
Quarter
Baseline

Experiment 2



Quarter

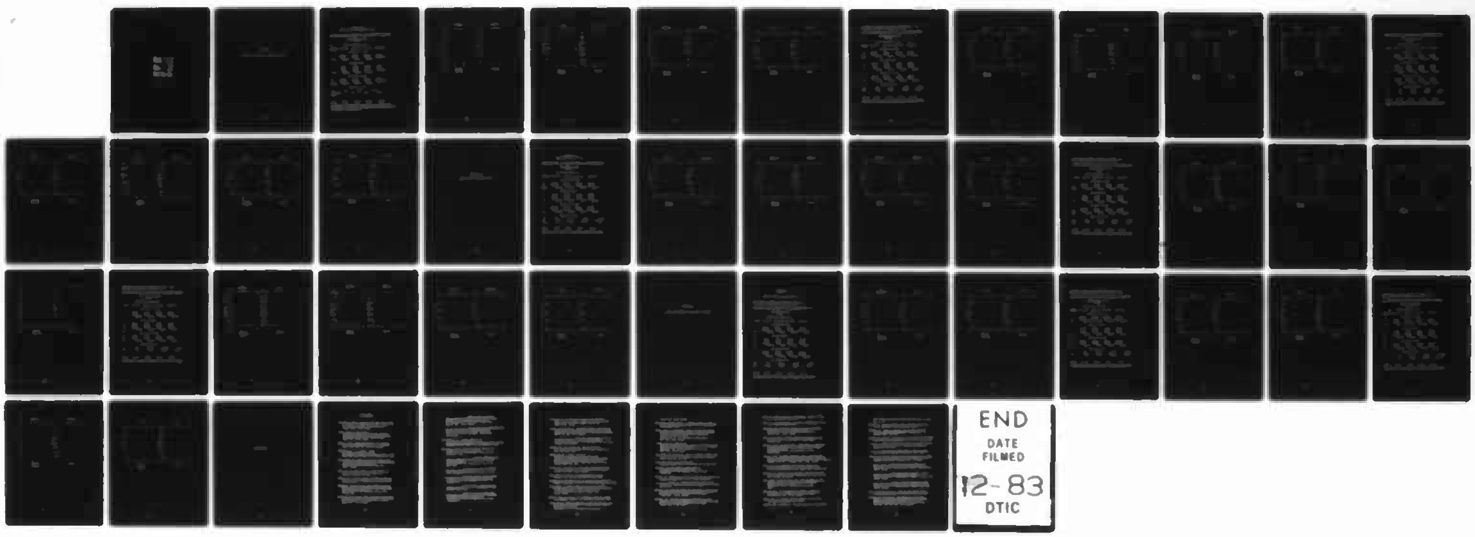

Rating
180
160
140
120
100
Percent
1
2
3
4
Quarter
Baseline

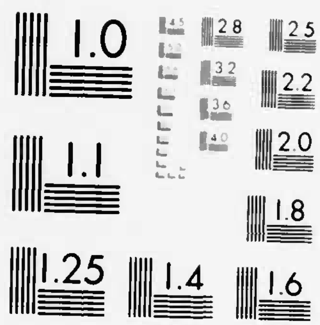

Rating
200
180
160
140
120
100
Percent
1
2
3
4
Quorter

AD-A134 949 EFFECTIVENESS MEASUREMENT IN THE MARINE CORPS REAL PROPERTY MAINTENANCE ACTIVITY(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF SYST.. W T MARSH

3/3

UNCLASSIFIED SEP 83 AFIT-LSSR-8-83 F/G 5/1 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

APPENDIX H

FUNDING AVAILABILITY EXPERIMENT FIGURES

Appendix H
Funding Availability Experiment Figures

****

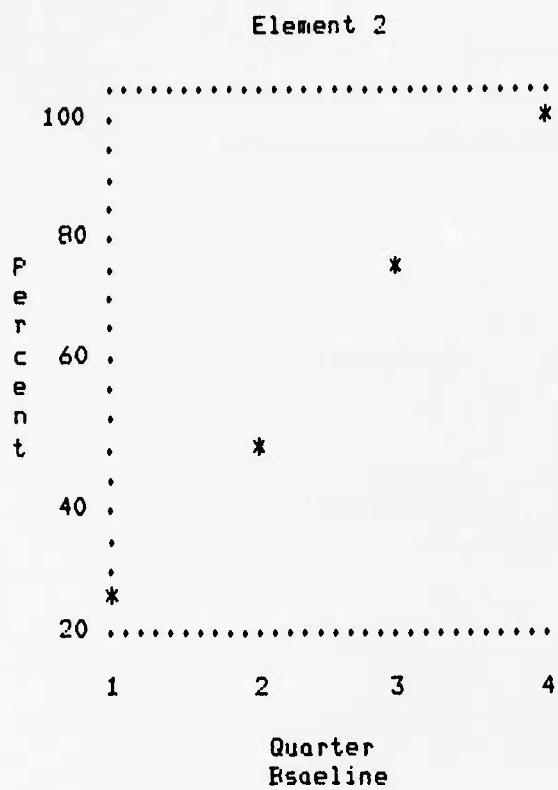
Camp Samuel Nicholas
(small)

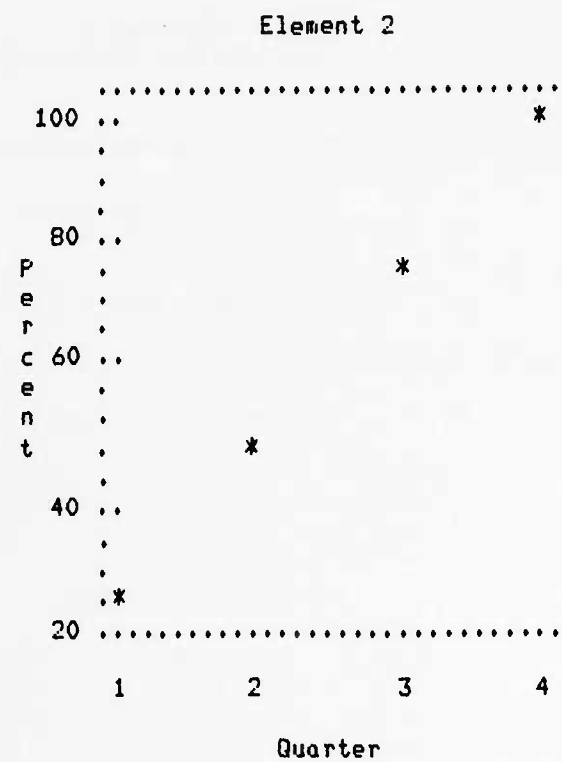
Effectiveness Report No. 6

Element	First Qtr	Second Qtr	Third Qtr	Fourth Qtr
		Productivity Factors		
1	100.00	100.00	100.00	100.00
2	24.63	50.78	75.99	100.00 Sum
124.63	150.78	175.99	200.00	
		Planning Factors		
3	22.42	47.05	70.40	93.30
4	9.09	9.09	9.09	12.73
5	74.55	74.55	80.00	72.73 Sum
106.05	130.69	159.49	178.76	
		Reliability Factors		
6	100.00	100.00	100.00	159.77
7	24.96	50.28	74.99	114.94 Sum
124.96	150.28	174.99	274.71	
		Initiation Factors		
8	.00	76.10	78.72	
143.00 Sum	.00	76.10	78.72	
143.00				
Rating	104.01	138.99	155.71	209.53

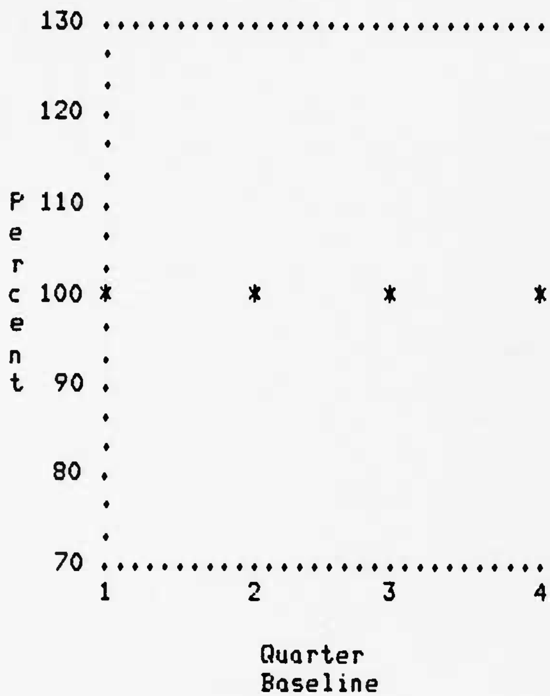
****

The following graphs represent the results of the Funding availability experiment for the smallest base.

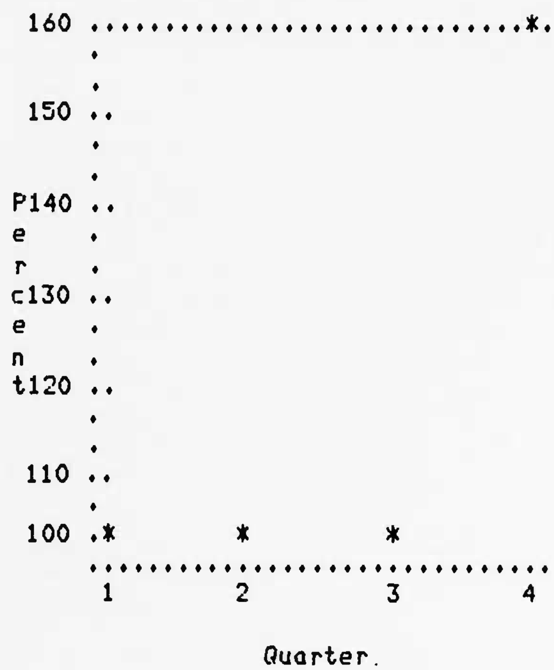

Element 2
100
80
60
40
20
Percent
1
2
3
4
Quarter
Bsaeline


Element 2
100
80
60
40
20
Percent
1
2
3
4
Quarter

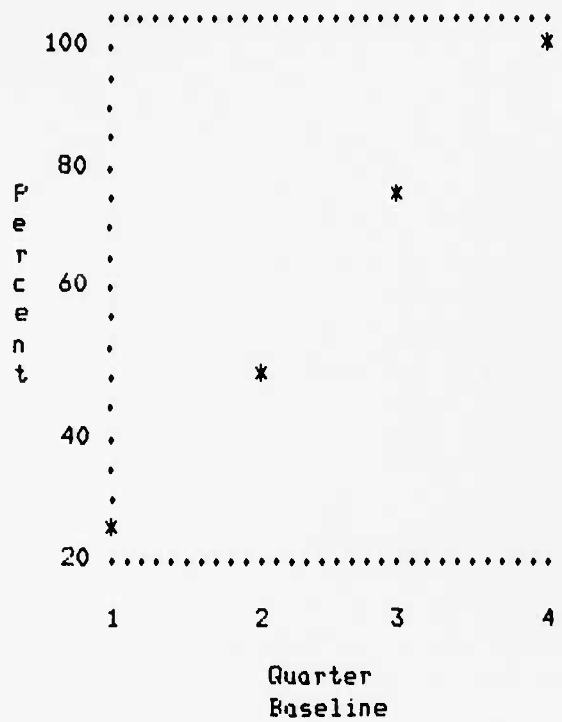
Element 6



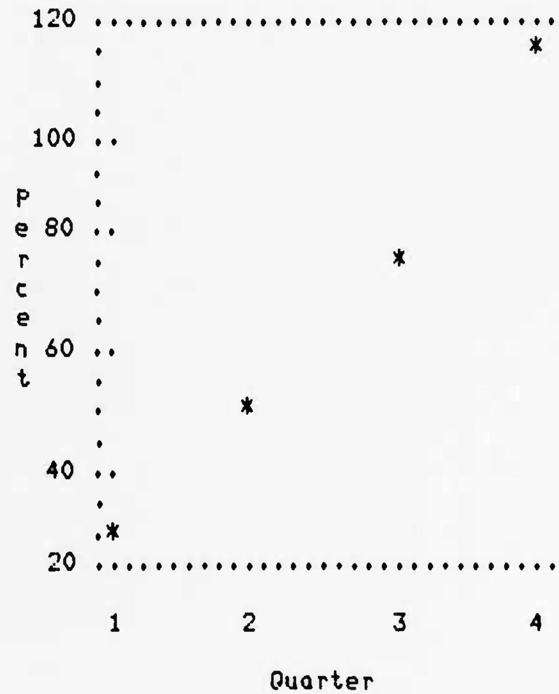
Element 6

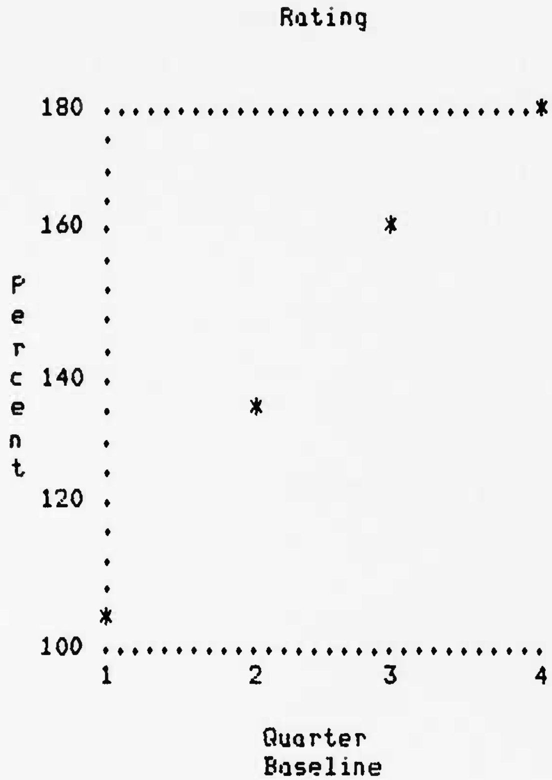


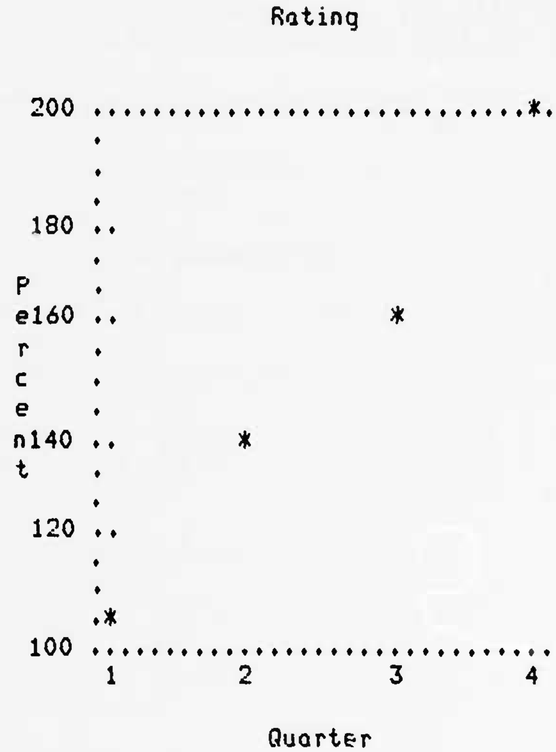
Element 7



Element 7




Rating
180
160
Percent
140
120
100
1
2
3
4
Quarter
Baseline


Rating
200
180
Percent
160
140
120
100
1
2
3
4
Quarter

The following information represents the results of the Funding availability experiment for the medium size base.

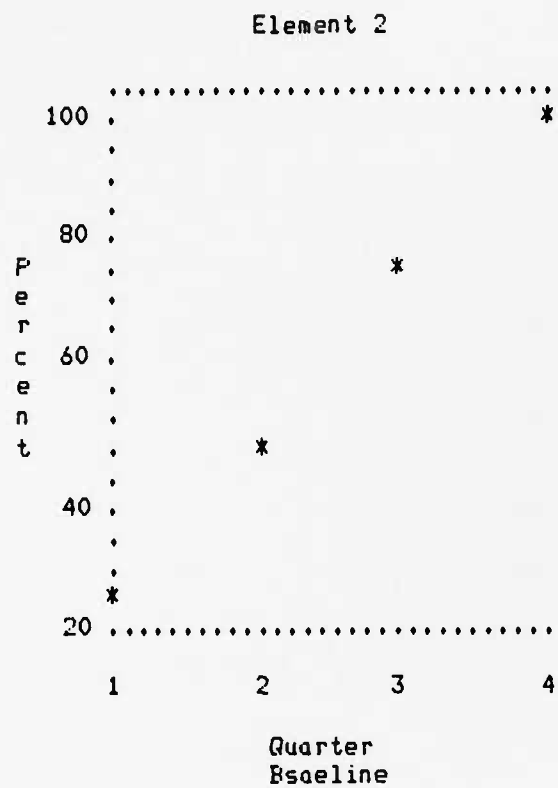
****

Camp William W. Burrows
(medium)

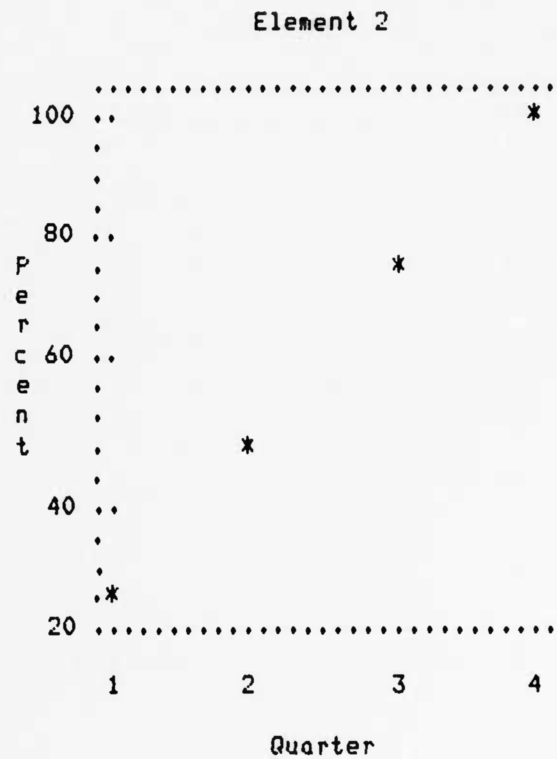
Effectiveness Report No. 6

Element	First Qtr	Second Qtr	Third Qtr	Fourth Qtr
		Productivity Factors		
1	100.18	99.95	100.03	99.83
2	25.66	50.01	75.23	100.00
Sum	125.85	149.97	175.26	199.83
		Planning Factors		
3	24.75	49.69	74.81	100.12
4	7.81	12.01	9.09	10.88
5	77.72	73.70	75.16	76.62
Sum	110.28	135.41	159.07	187.62
		Reliability Factors		
6	100.19	100.03	99.98	150.95
7	25.17	50.09	75.05	112.77
Sum	125.36	150.12	175.03	263.72
		Initiation Factors		
8	.00	74.01	73.86	141.81
Sum	.00	74.01	73.86	141.81
Rating	106.94	134.27	159.51	201.07

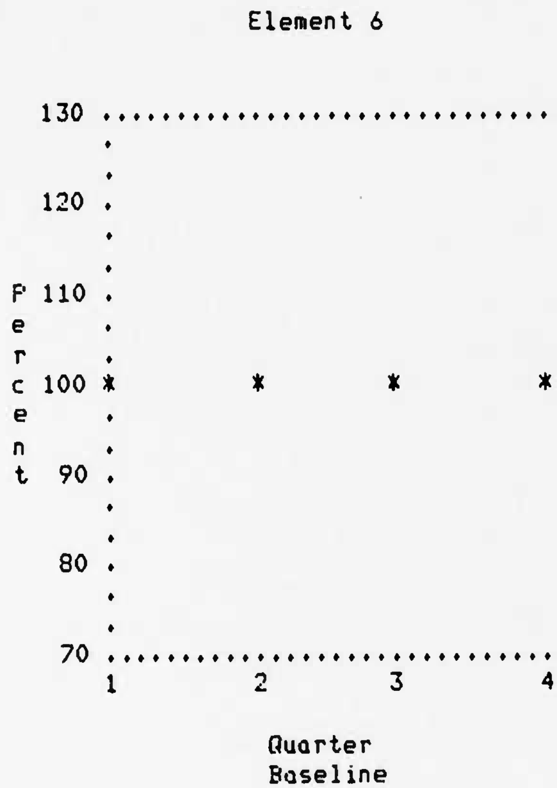
****

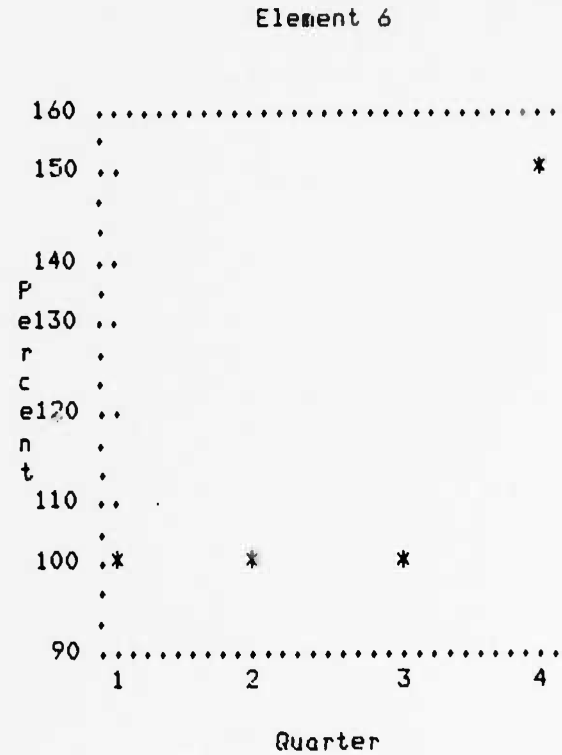


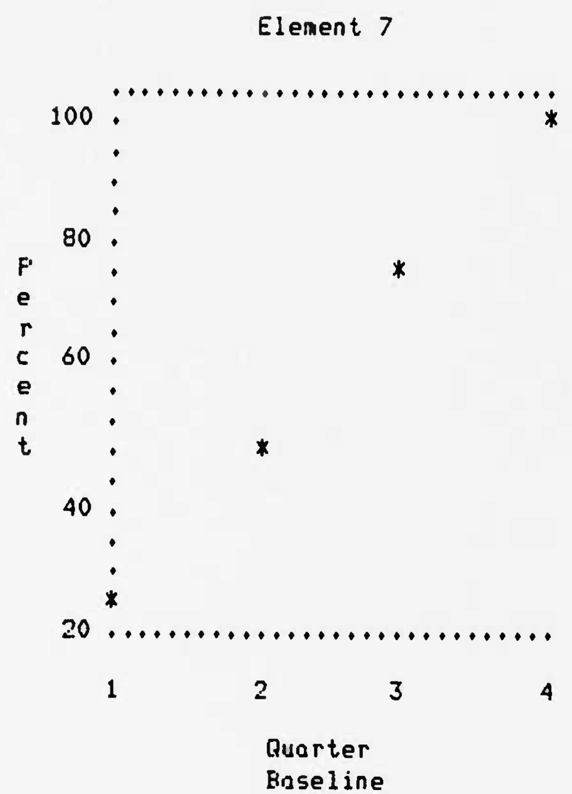
Element 2
100
80
60
40
20
Percent
1
2
3
4
Quarter
Bsaeline

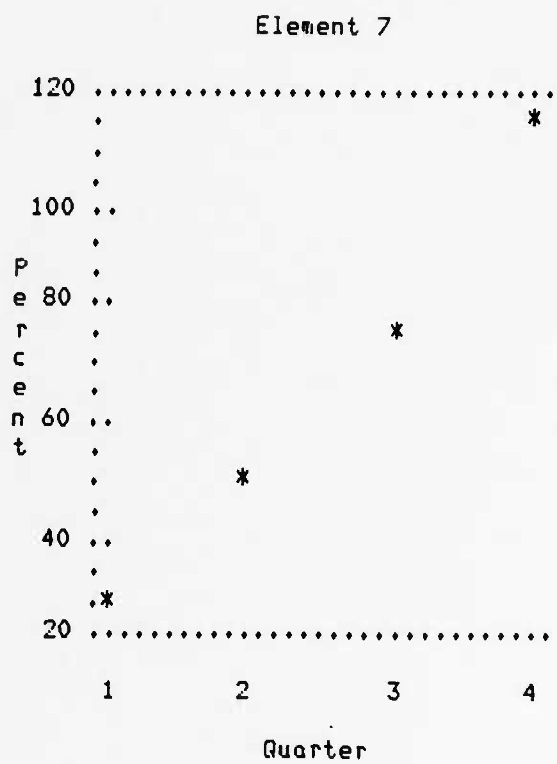


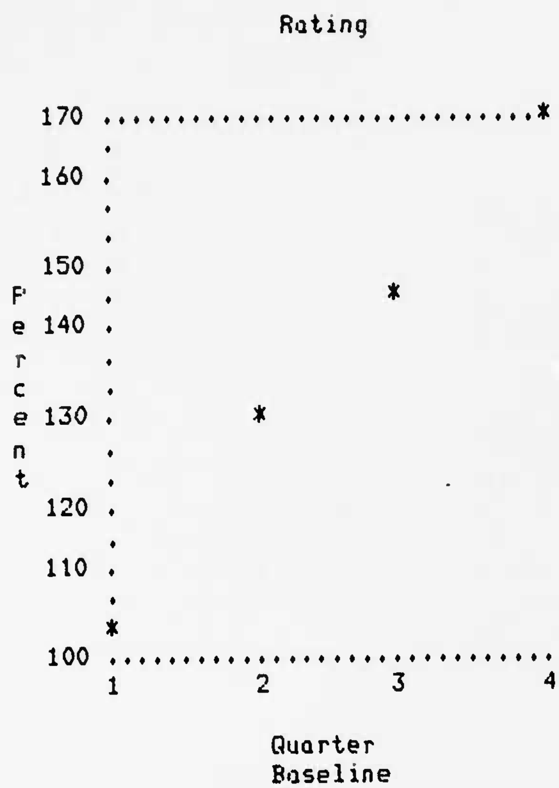
Element 2
100
80
60
40
20
Percent
1
2
3
4
Quarter

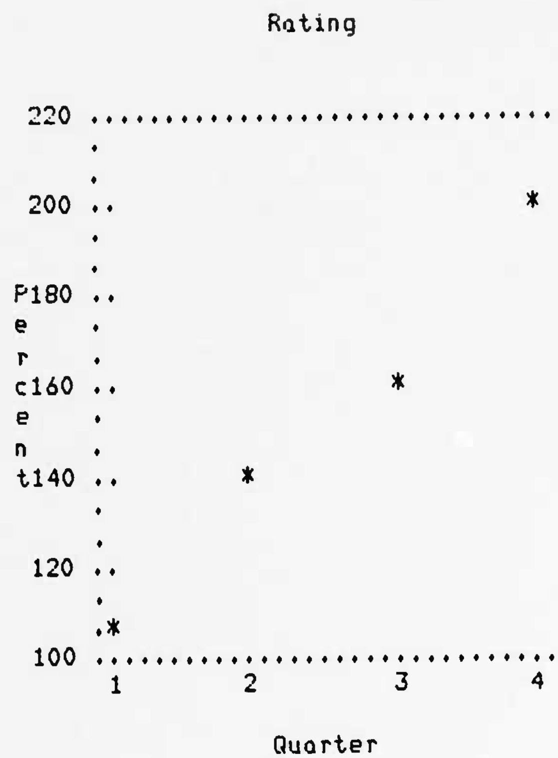

Element 6
130
120
110
100
90
80
70
Percent
1
2
3
4
Quarter
Baseline


Element 6
160
150
140
130
120
110
100
90
Percent
1
2
3
4
Quarter


Element 7
Percent
100
80
60
40
20
1
2
3
4
Quarter
Baseline


Element 7
Percent
120
100
80
60
40
20
1
2
3
4
Quarter


Rating
170
160
150
140
130
120
110
100
Percent
1
2
3
4
Quarter
Baseline


Rating
220
200
180
160
140
120
100
Percent
1
2
3
4
Quarter

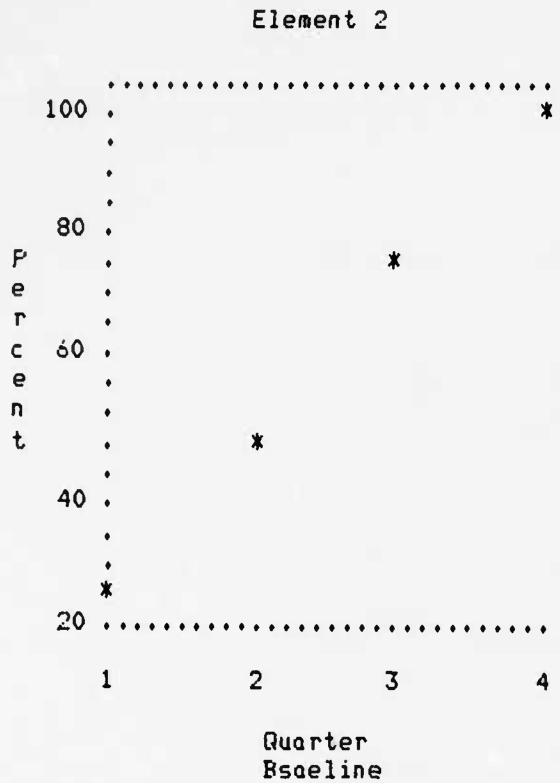
****

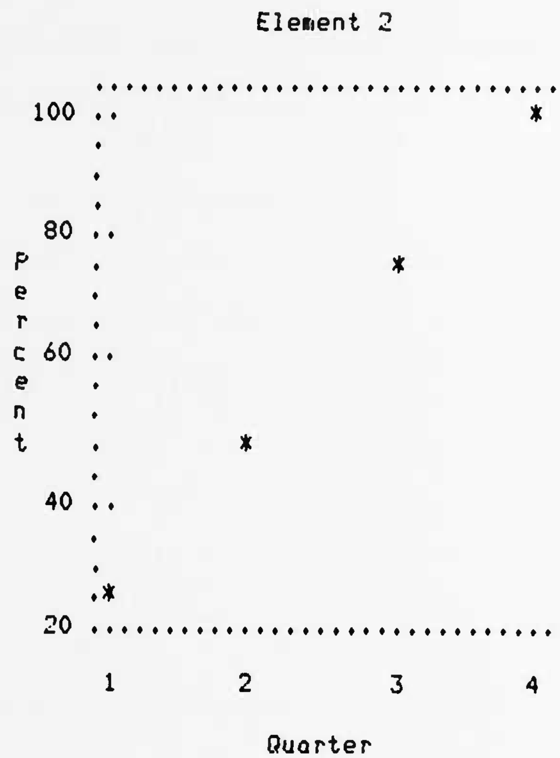
Camp Presly N. OBannon
(large)

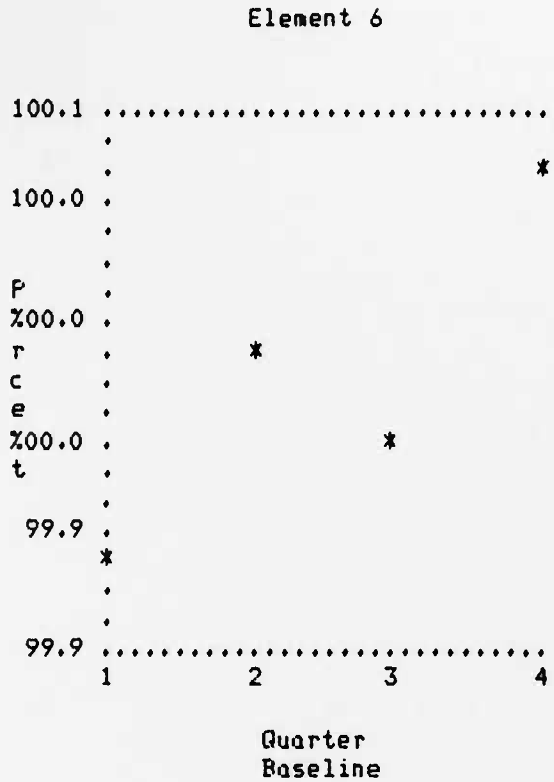
Effectiveness Report No. 6

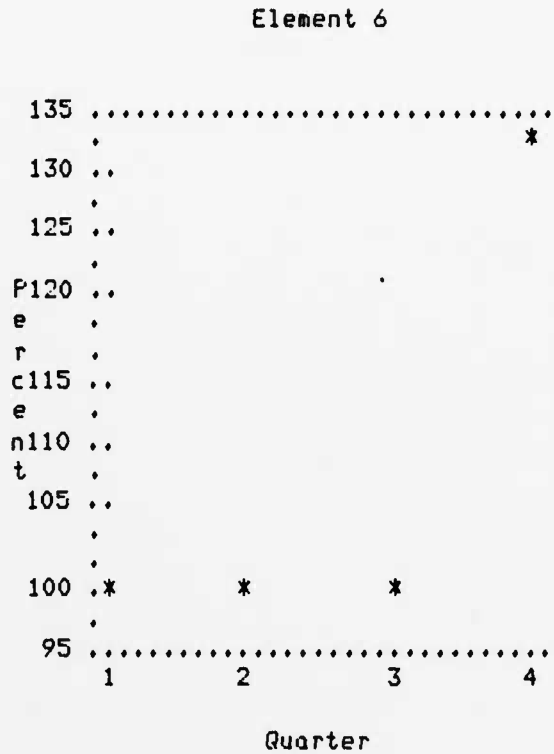
Element	First Qtr	Second Qtr	Third Qtr	Fourth Qtr
	Productivity Factors			
1	99.88	99.95	99.98	100.09
2	24.81	49.71	74.84	99.98
Sum	124.69	149.66	174.82	200.07
	Planning Factors			
3	23.97	47.99	71.95	95.91
4	9.97	10.19	10.32	10.57
5	74.33	74.59	74.90	75.21
Sum	108.27	132.78	157.18	181.69
	Reliability Factors			
6	99.86	100.00	99.92	131.80
7	24.97	49.97	74.91	107.92
Sum	124.83	149.96	174.83	239.72
	Initiation Factors			
8	.00	74.61	74.42	114.65
Sum	.00	74.61	74.42	114.65
Rating	104.60	134.75	157.59	179.23

****


Element 2
100
80
60
40
20
Percent
1
2
3
4
Quarter
Bsaeline


Element 2
100
80
60
40
20
Percent
1
2
3
4
Quarter


Element 6
100.1
100.0
P
%00.0
r
c
e
%00.0
t
99.9
99.9
1
2
3
4
Quarter
Baseline


Element 6
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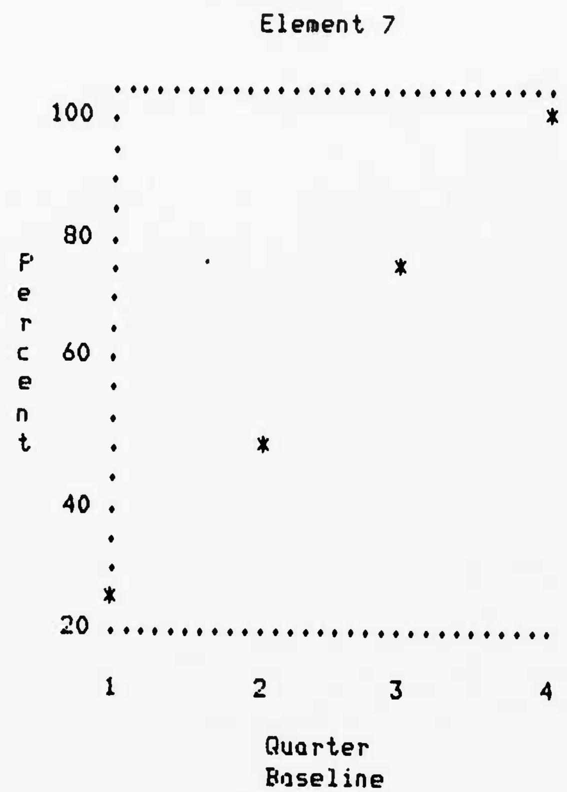
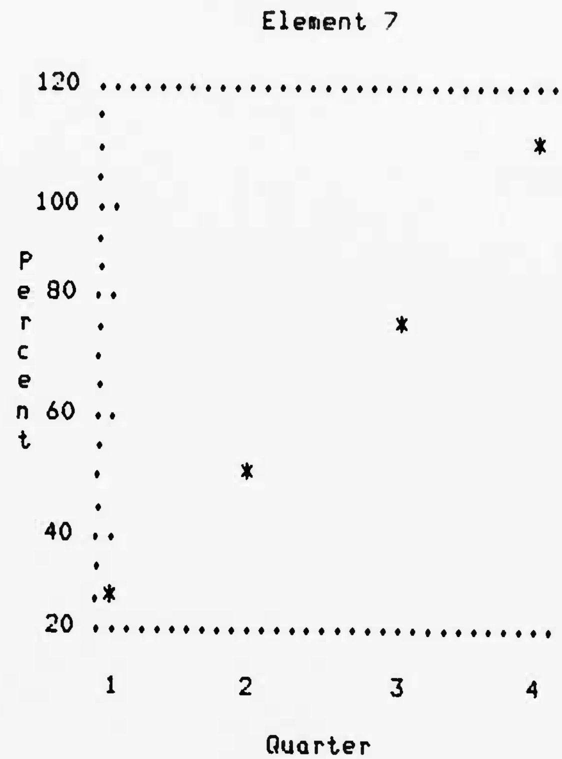
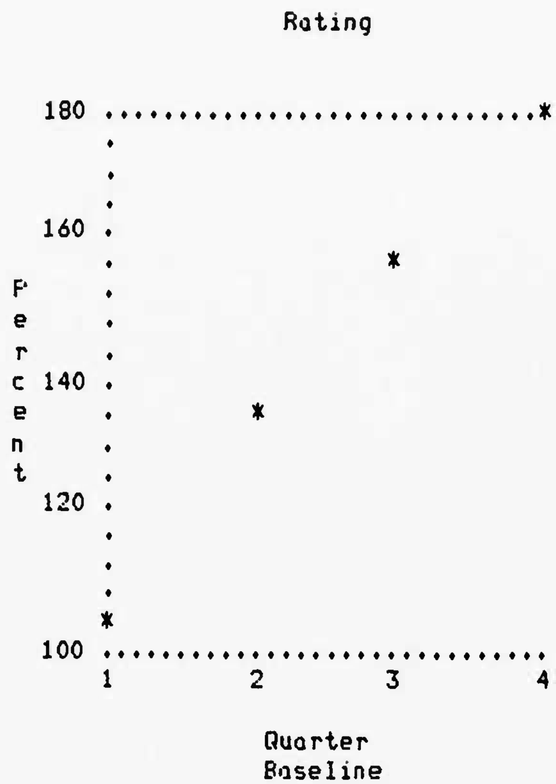
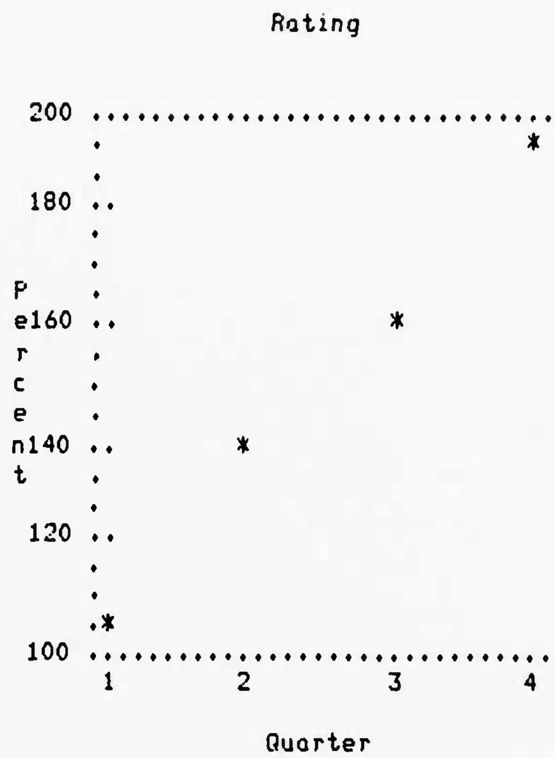
130
125
P120
e
r
c115
e
n110
t
105
100
95
1
2
3
4
Quarter


Element 7
100
80
60
40
20
Percent
1
2
3
4
Quarter
Baseline


Element 7
120
100
80
60
40
20
Percent
1
2
3
4
Quarter


Rating
180
160
140
120
100
Percent
1
2
3
4
Quarter
Baseline


Rating
200
180
160
140
120
100
Percent
1
2
3
4
Quarter

APPENDIX I

PROGRAMMING EXPERIMENT FIGURES

Appendix I
Programming Experiment Figures

****

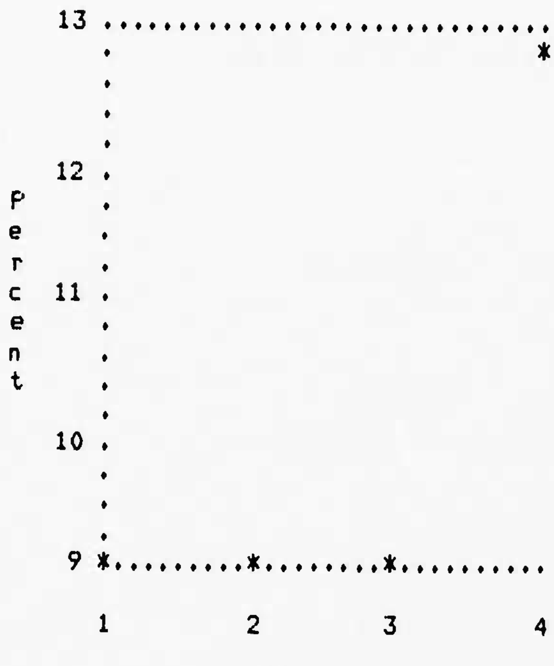
Comp Samuel Nicholas
(small)

Effectiveness Report No. 6

Element	First Qtr	Second Qtr	Third Qtr	Fourth Qtr
	Productivity Factors			
1	100.00	100.00	100.00	100.00
2	24.63	50.78	75.99	100.00
Sum	124.63	150.78	175.99	200.00
	Planning Factors			
3	22.42	47.05	70.40	93.30
4	27.27	27.27	27.27	34.55
5	52.73	56.36	52.73	50.91
Sum	102.42	130.69	150.40	178.76
	Reliability Factors			
6	100.00	100.00	100.00	100.00
7	24.96	50.28	74.99	100.00
Sum	124.96	150.28	174.99	200.00
	Initiation Factors			
8	.00	79.74	69.63	77.38
Sum	.00	79.74	69.63	77.38
Rating	99.01	149.19	160.71	176.42

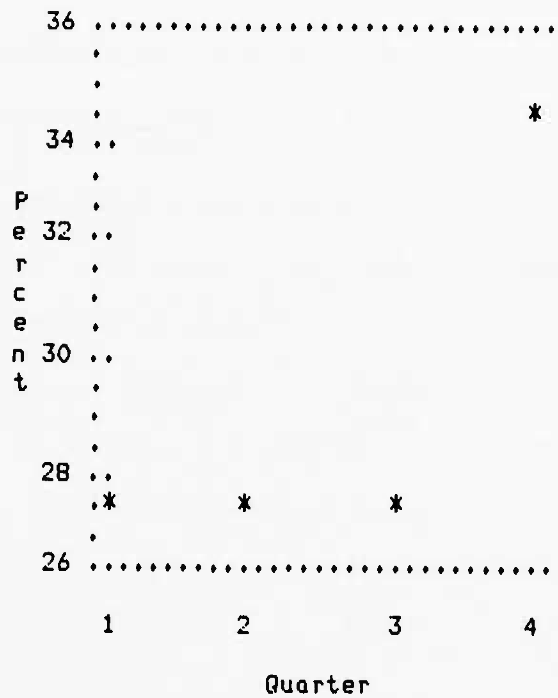
****

Element 4



Baseline

Element 4



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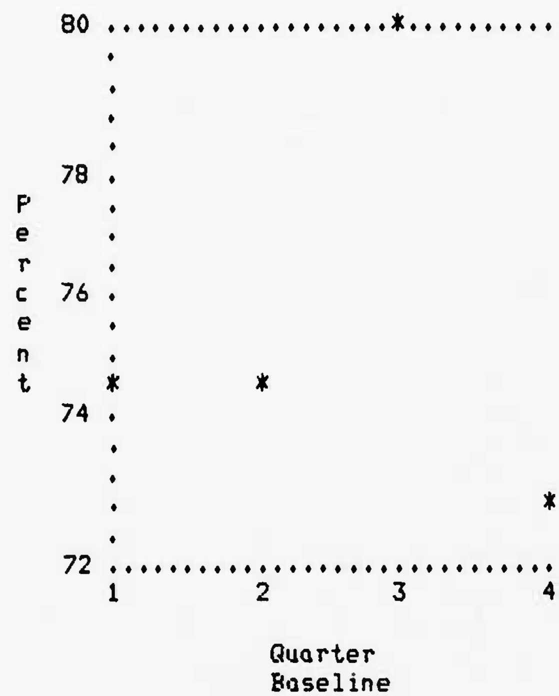

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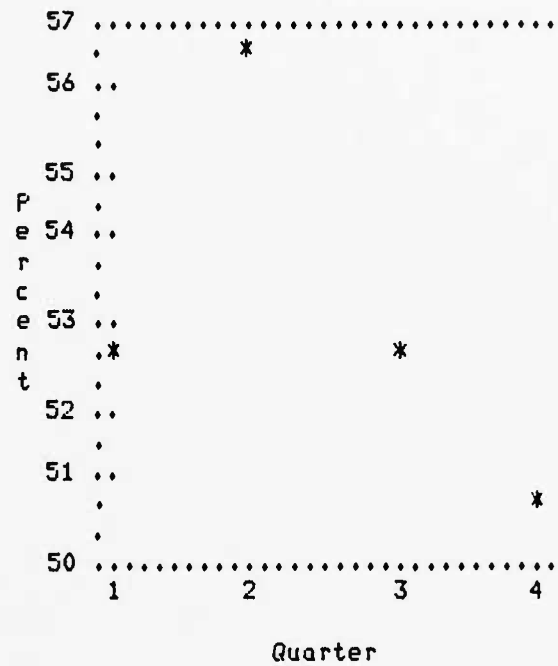

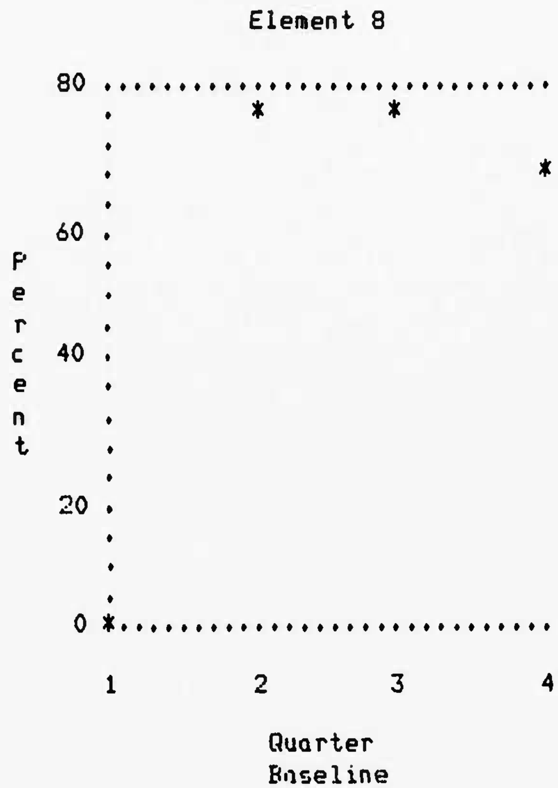
Element 8
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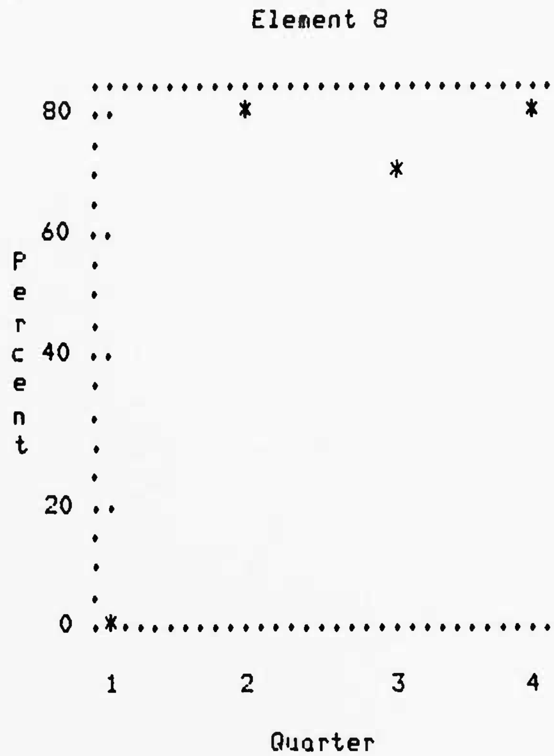
60
40
20
0
Percent
1
2
3
4
Quarter
Baseline


Element 8
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Percent
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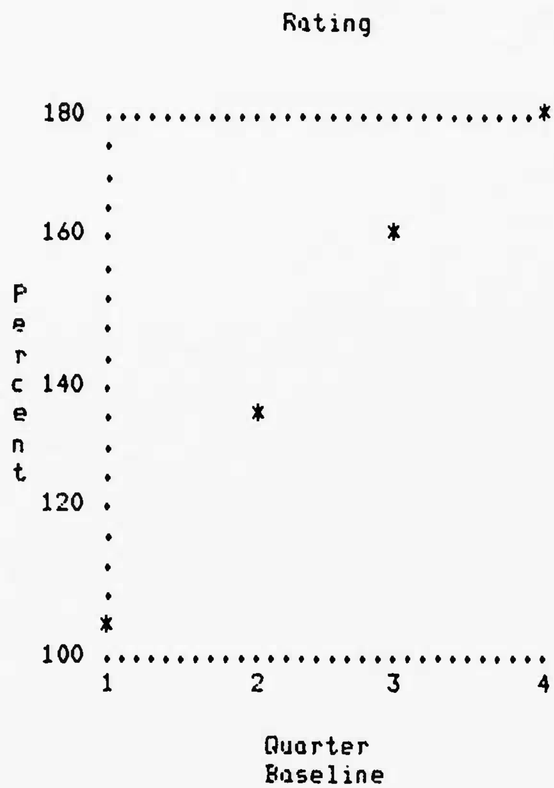
4
Quarter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Percent
140
120
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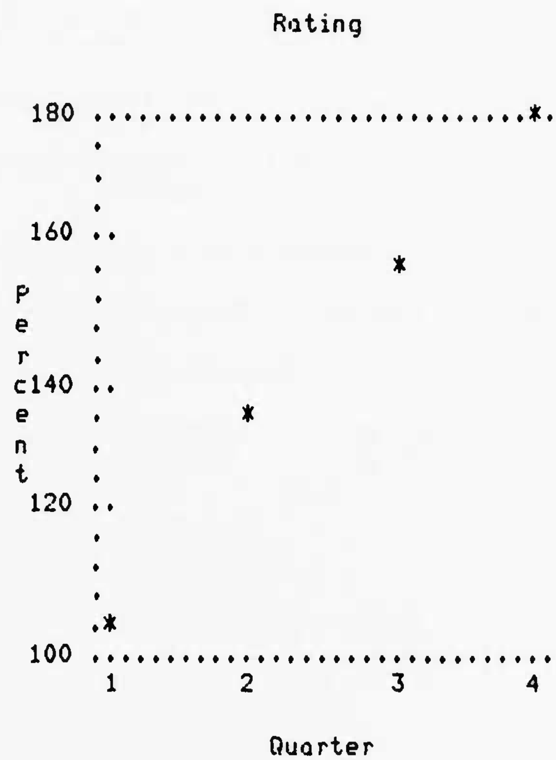
1
2
3
4
Quarter
Baseline


Rating
180
160
Percent
140
120
100
1
2
3
4
Quarter

The following information represents the results of the programming experiment for the medium size base.

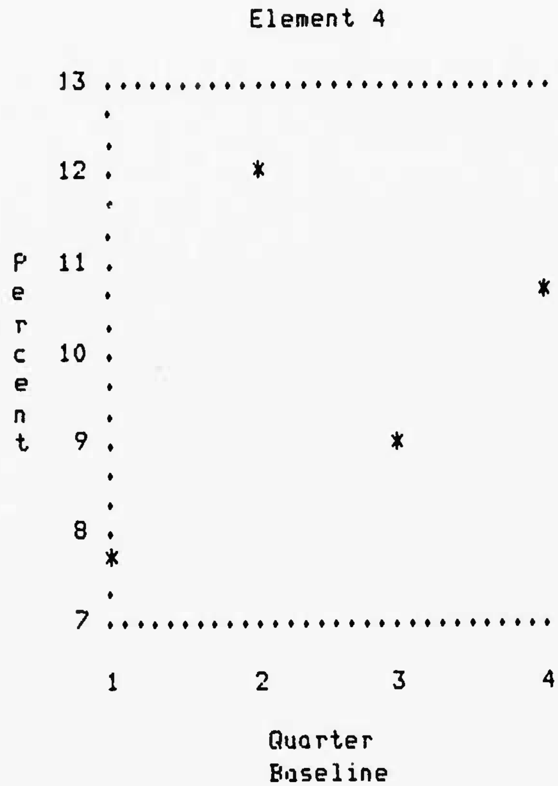
****

Camp William W. Burrows
(medium)

Effectiveness Report No. 6

Element	First Qtr	Second Qtr	Third Qtr	Fourth Qtr
	Productivity Factors			
1	100.00	100.00	100.00	100.00
2	25.65	50.00	75.20	100.00
Sum	125.65	150.00	175.20	200.00
	Planning Factors			
3	24.75	49.69	74.81	100.12
4	17.86	21.27	19.81	19.64
5	53.41	47.56	50.00	48.86
Sum	96.02	118.52	144.62	168.62
	Reliability Factors			
6	100.00	100.00	100.00	100.00
7	25.16	50.06	75.02	100.00
Sum	125.16	150.06	175.02	200.00
	Initiation Factors			
8	.00	71.76	76.24	73.79
Sum	.00	71.76	76.24	73.79
Rating	101.13	131.18	155.49	180.37

****


Element 4
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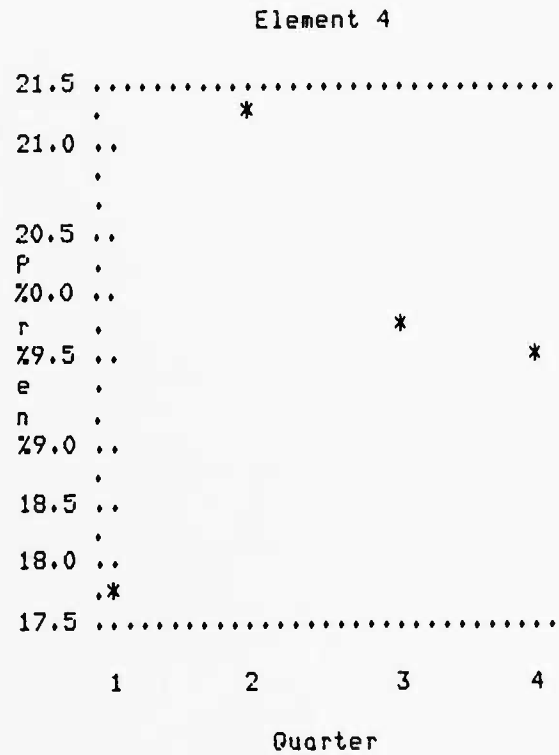
12
11
10
9
8
7
Percent
1
2
3
4
Quarter
Baseline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20.5
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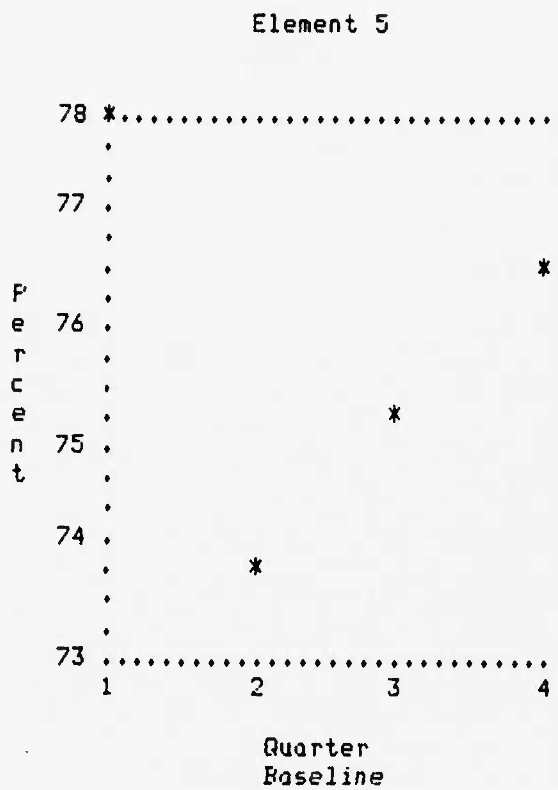
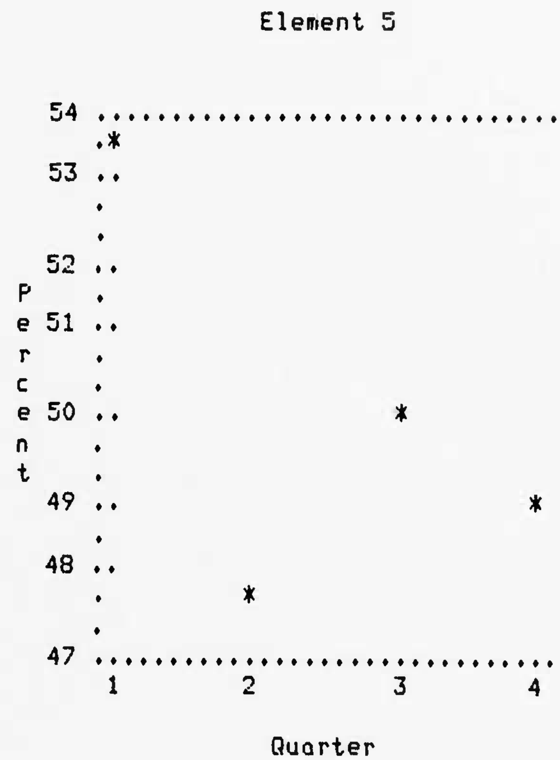
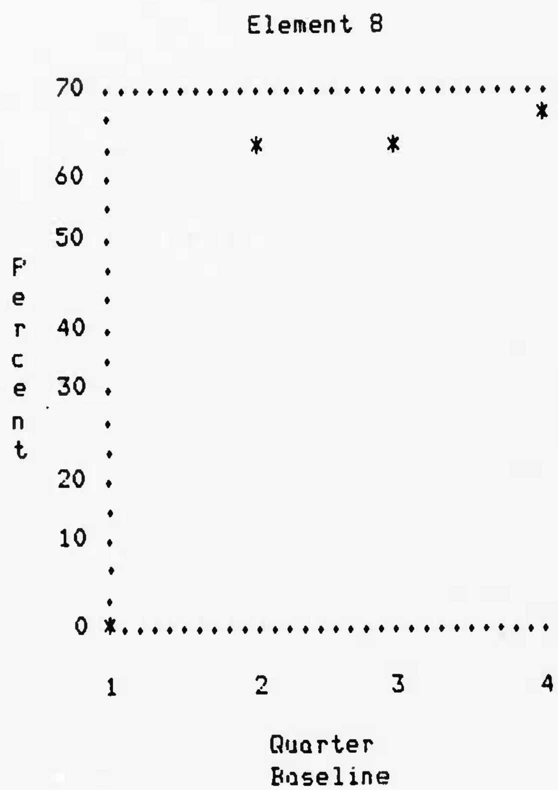
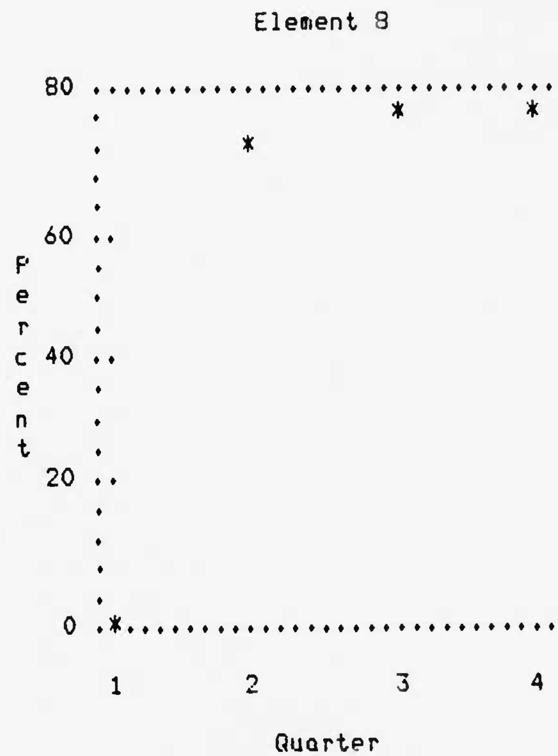
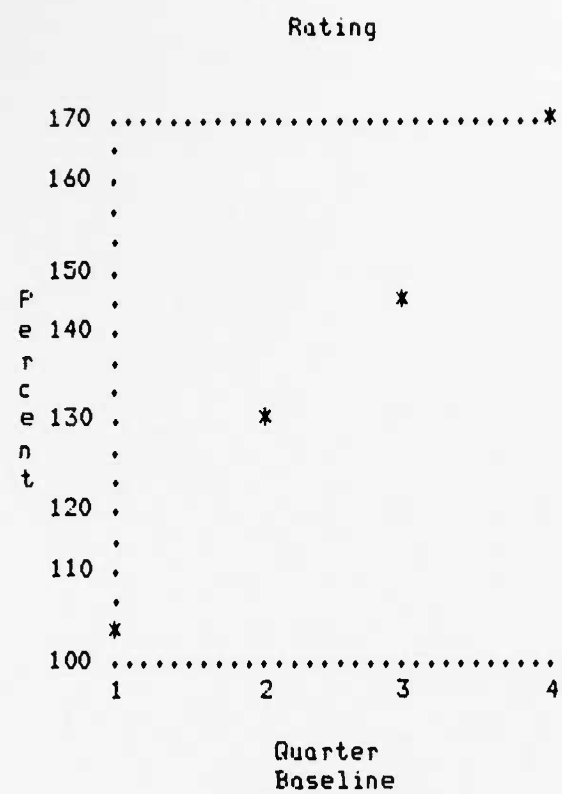
%9.5
%9.0
18.5
18.0
17.5
Percent
1
2
3
4
Quarter

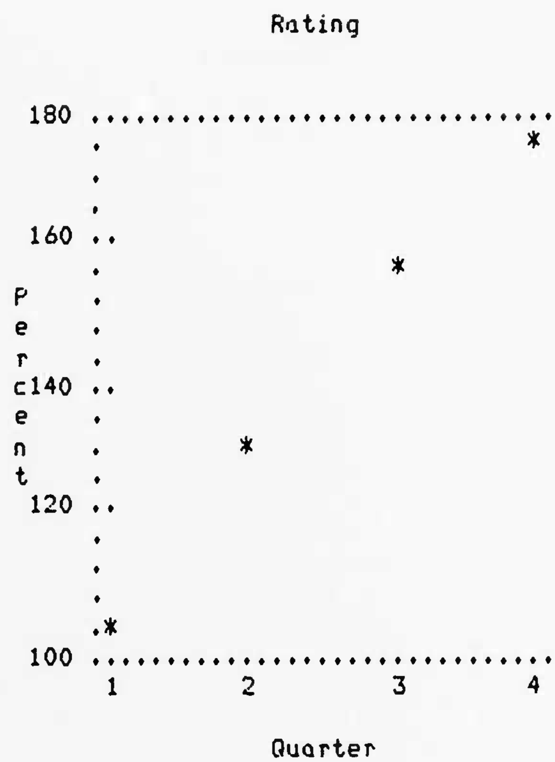

Element 5
78
77
76
75
74
73
Percent
1
2
3
4
Quarter
Baseline


Element 5
54
53
52
51
50
49
48
47
Percent
1
2
3
4
Quarter


Element 8
70
60
50
40
30
20
10
0
Percent
1
2
3
4
Quarter
Baseline


Element 8
80
60
40
20
0
Percent
1
2
3
4
Quarter


Rating
170
160
150
140
130
120
110
100
Percent
1
2
3
4
Quarter
Baseline


Rating
180
160
140
120
100
Percent
1
2
3
4
Quarter

The following information represents the results of the programming experiment at the largest base.

****

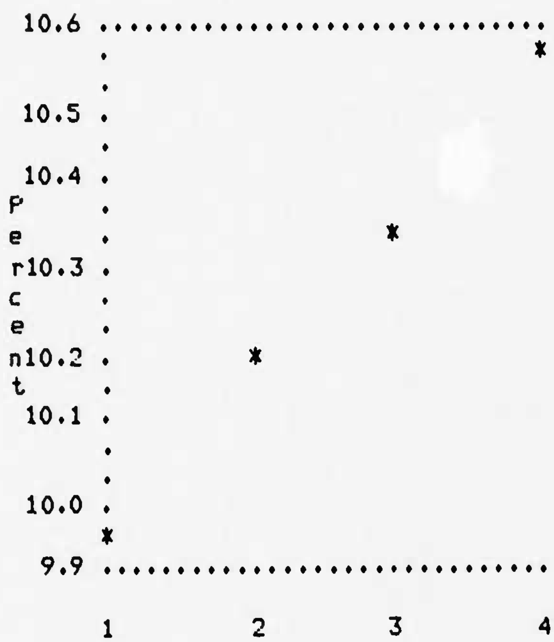
Camp Presly N. OBannon
(large)

Effectiveness Report No. 6

Element	First Qtr	Second Qtr	Third Qtr	Fourth Qtr
		Productivity Factors		
1	99.88	99.95	99.98	100.02
2	24.81	49.71	74.84	99.96
Sum	124.69	149.66	174.82	199.98
		Planning Factors		
3	23.97	47.99	71.95	95.91
4	30.78	30.50	29.66	29.48
5	49.30	50.15	50.34	49.82
Sum	104.05	128.64	151.95	175.21
		Reliability Factors		
6	99.86	100.00	99.92	100.10
7	24.97	49.97	74.91	99.97
Sum	124.83	149.96	174.83	200.07
		Initiation Factors		
8	.00	74.69	73.33	73.67
Sum	.00	74.69	73.33	73.67
Rating	104.06	135.30	156.21	177.57

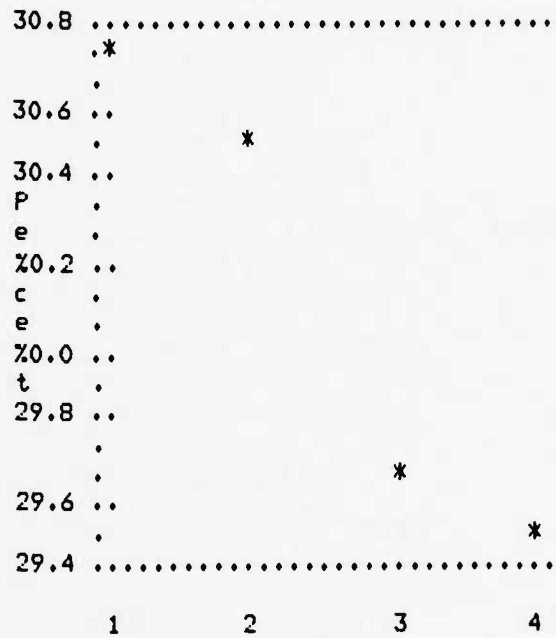
****

Element 4



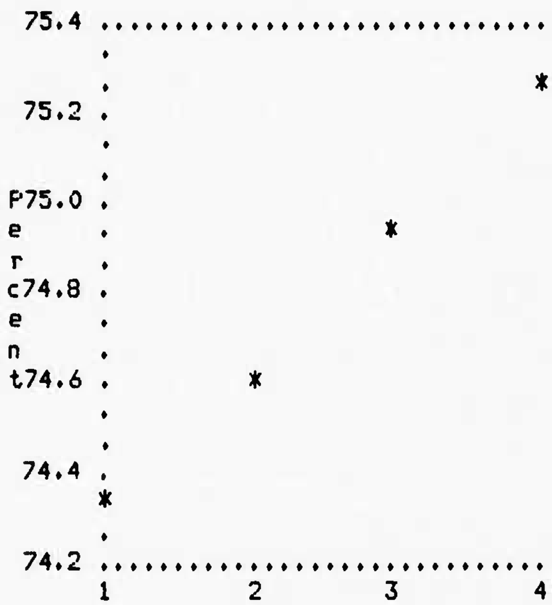
Quarter
Baseline

Element 4



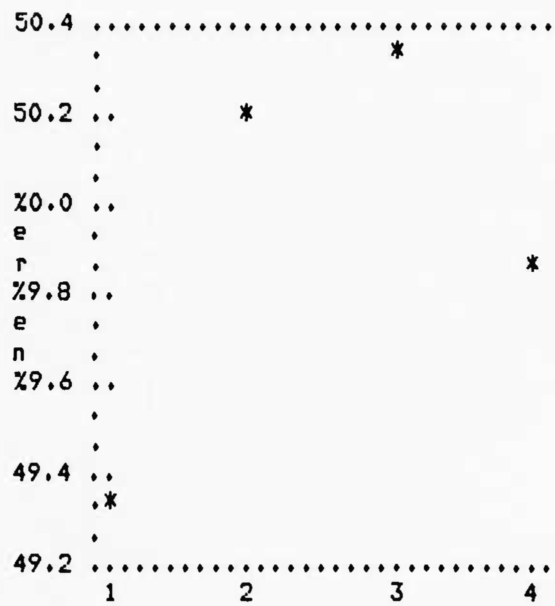
Quarter

Element 5

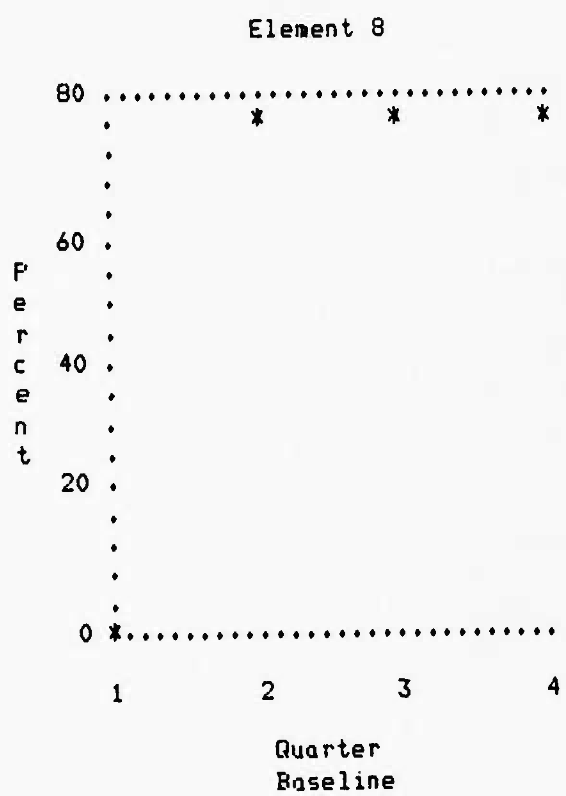


Quarter
Baseline

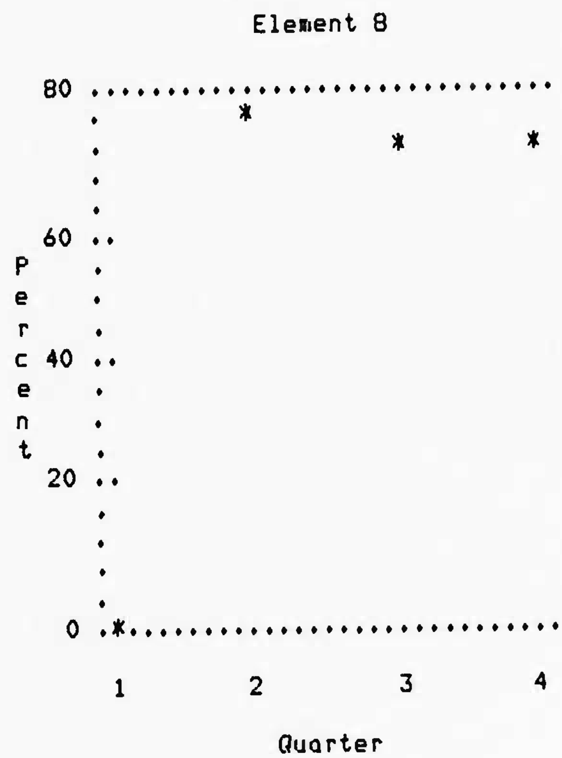
Element 5



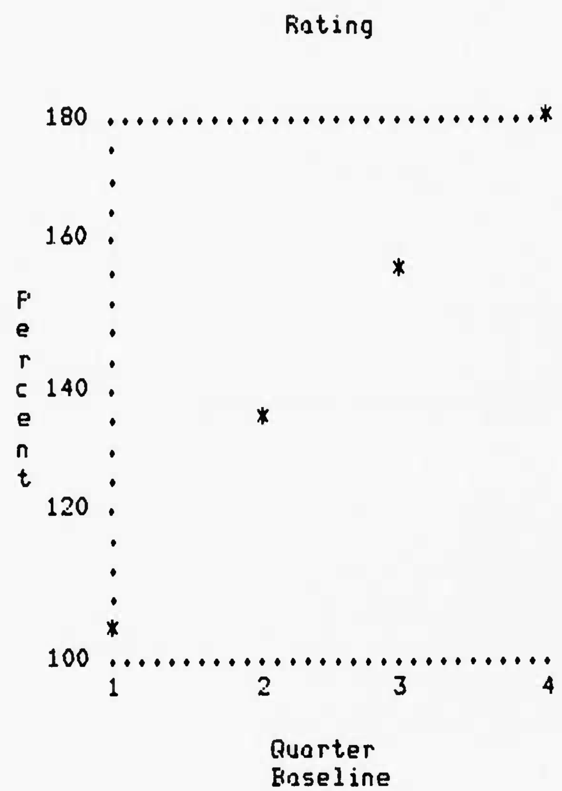
Quarter



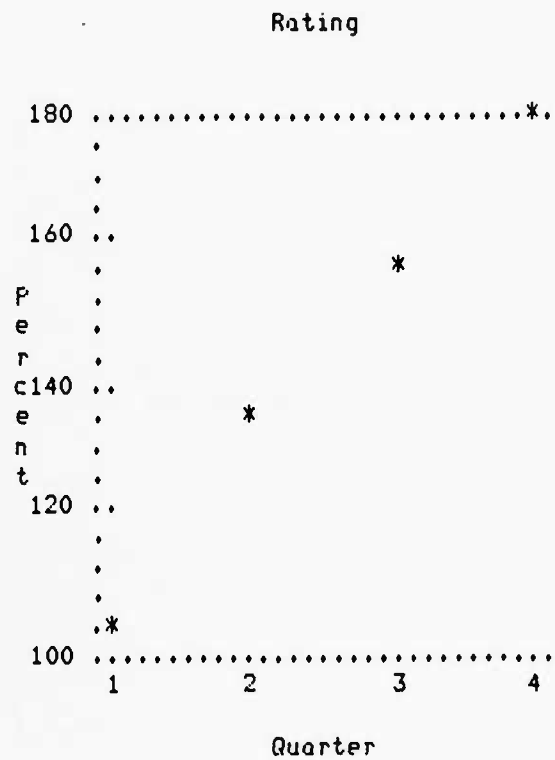
Element 8
80
60
40
20
0
Percent
1
2
3
4
Quarter
Baseline



Element 8
80
60
40
20
0
Percent
1
2
3
4
Quarter



Rating
180
160
140
120
100
Percent
1
2
3
4
Quarter
Baseline



Rating
180
160
140
120
100
Percent
1
2
3
4
Quarter

APPENDIX J

LEVEL OF INSPECTION EXPERIMENT FIGURES

APPENDIX J

Level of Inspection Experiment Results

The following information represents the results of the Level of Inspection Experiment for the smallest base.

****

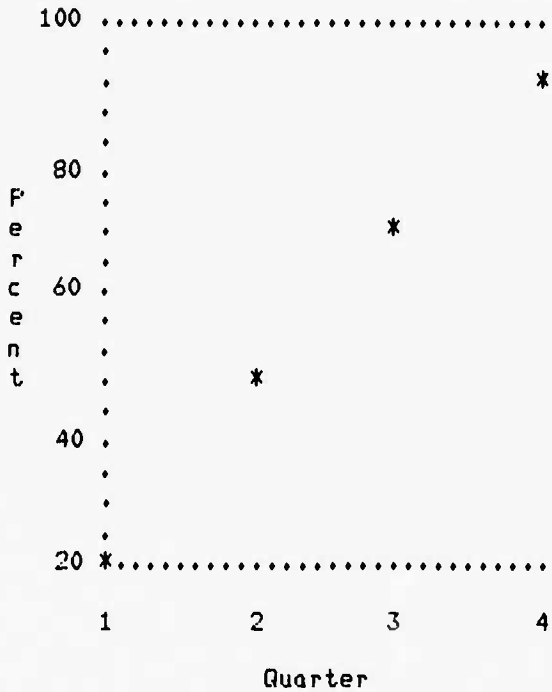
Camp Samuel Nicholas
(small)

Effectiveness Report No. 6

Element	First Qtr	Second Qtr	Third Qtr	Fourth Qtr
	Productivity Factors			
1	100.00	100.00	105.60	93.97
2	24.63	50.78	77.43	100.00
Sum	124.63	150.78	183.03	193.97
	Planning Factors			
3	5.27	12.77	18.97	24.73
4	9.09	9.09	9.09	12.73
5	74.55	74.55	80.00	72.73
Sum	88.91	96.41	108.06	110.19
	Reliability Factors			
6	100.00	100.00	106.45	113.54
7	24.96	50.28	76.58	104.99
Sum	124.96	150.28	183.03	218.53
	Initiation Factors			
8	.00	58.96	76.65	48.57
Sum	.00	58.96	76.65	48.57
Rating	99.72	128.19	140.62	175.81

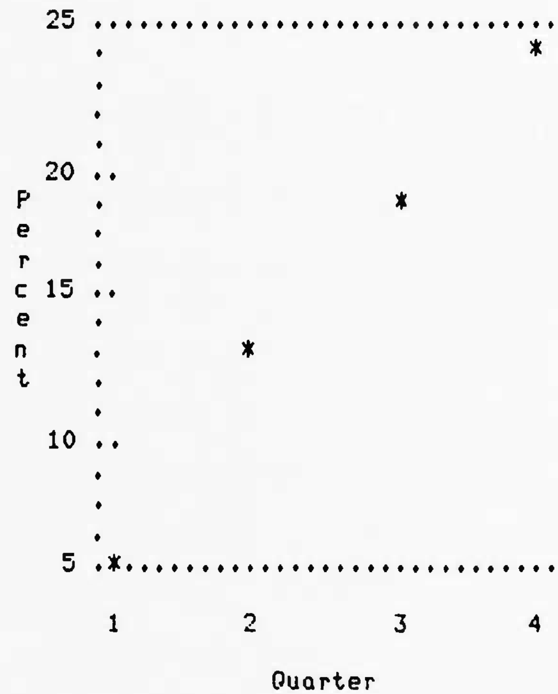
****

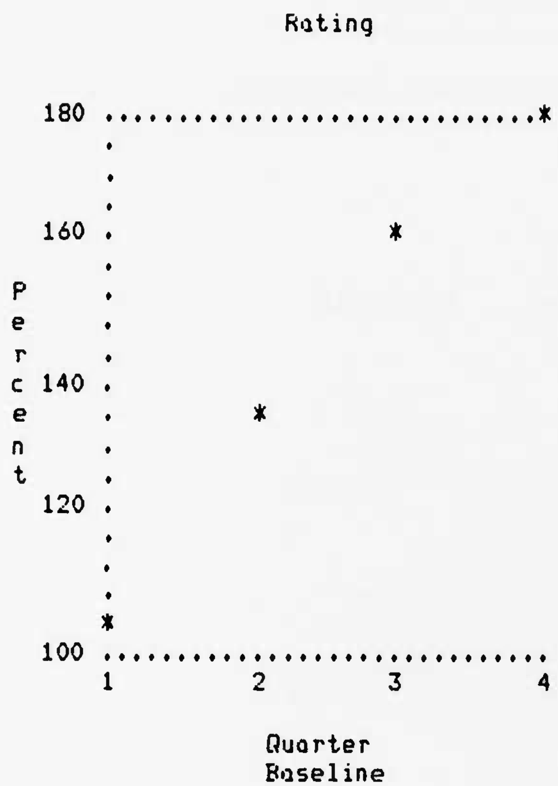
Element 3

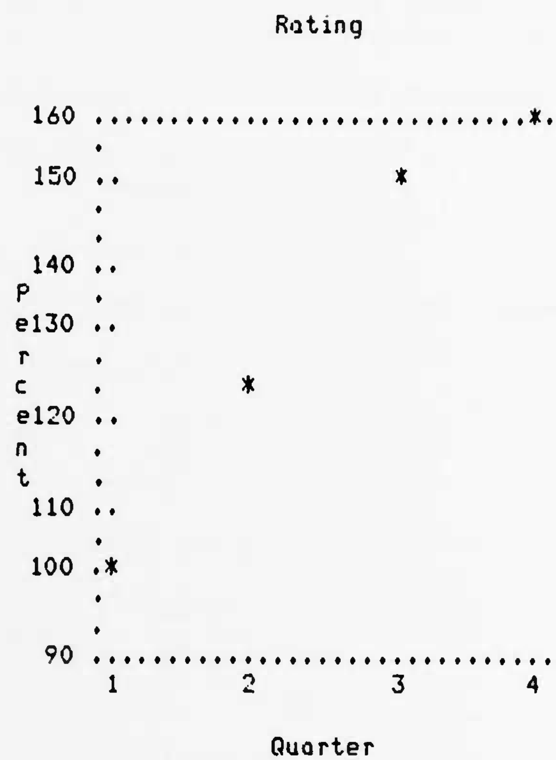


Baseline

Element 3




Rating
180
160
140
120
100
Percent
1
2
3
4
Quarter
Baseline


Rating
160
150
140
130
120
110
100
90
Percent
1
2
3
4
Quarter

The following information represents the results of the Level of Inspection experiment for the medium size base.

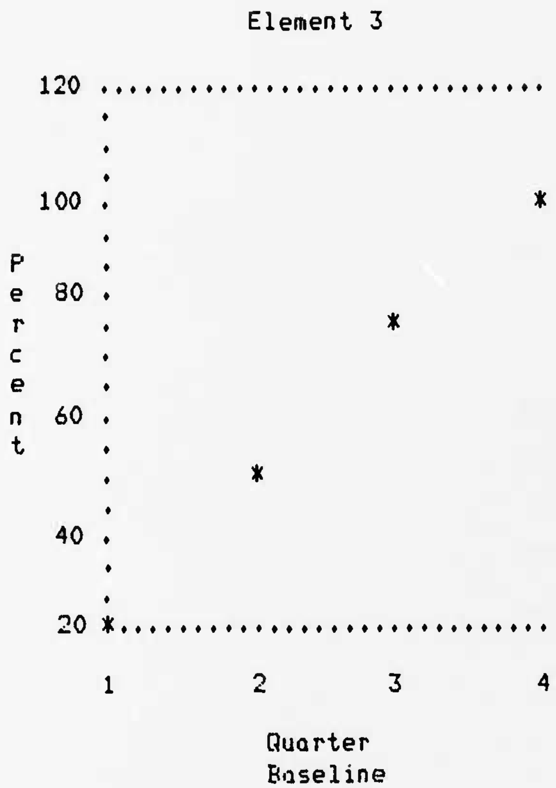
****

Camp William W. Burrows
(medium)

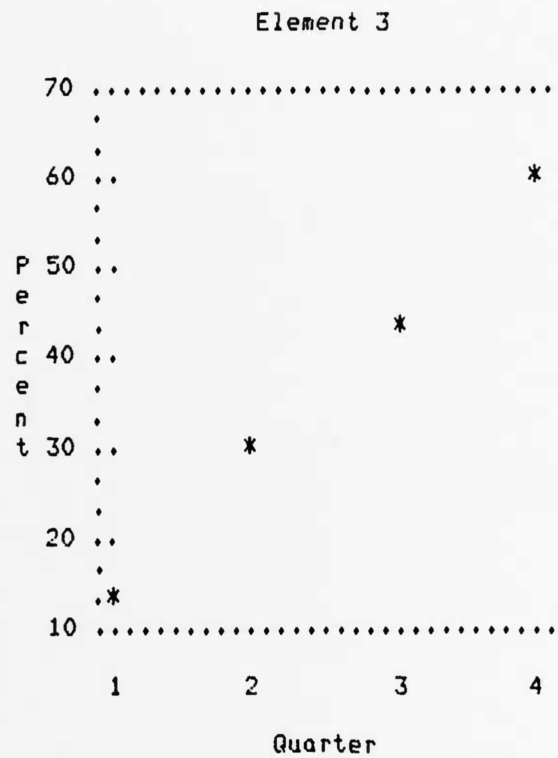
Effectiveness Report No. 6

Element	First Qtr	Second Qtr	Third Qtr	Fourth Qtr
		Productivity Factors		
1	100.00	100.00	100.00	100.00
2	25.65	50.00	75.20	100.00
Sum	125.65	150.00	175.20	200.00
		Planning Factors		
3	14.75	29.69	44.81	60.12
4	7.79	12.01	9.09	10.88
5	77.76	73.70	75.16	76.62
Sum	100.31	115.41	129.07	147.62
		Reliability Factors		
6	100.00	100.00	100.00	100.00
7	25.16	50.06	75.02	100.00
Sum	125.16	150.06	175.02	200.00
		Initiation Factors		
8	.00	64.36	63.81	68.34
Sum	.00	64.36	63.81	68.34
Rating	104.44	127.97	150.71	170.37

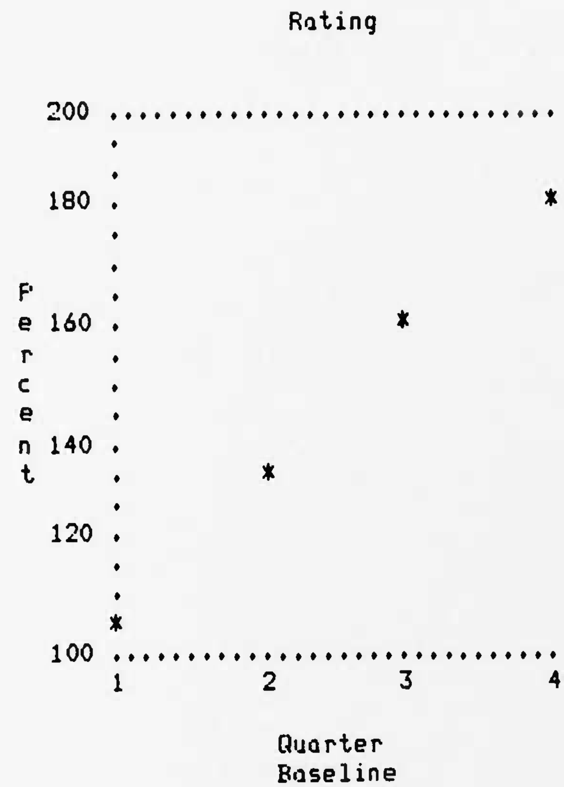
****



Element 3
120
100
80
60
40
20
Percent
1
2
3
4
Quarter
Baseline



Element 3
70
60
50
40
30
20
10
Percent
1
2
3
4
Quarter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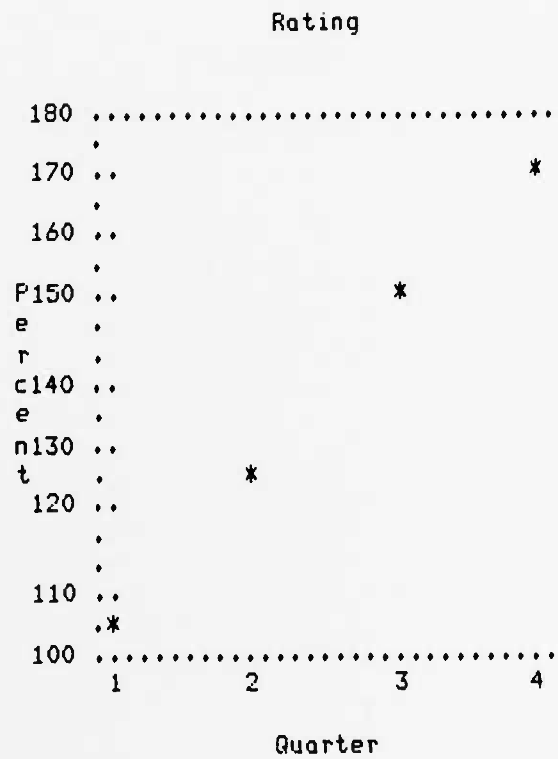
180
160
140
120
100
Percent
1
2
3
4
Quarter
Baseline


Rating
180
170
160
150
140
130
120
110
100
Percent
1
2
3
4
Quarter

The following information represents the results of the Level of inspection experiment for the largest base.

****

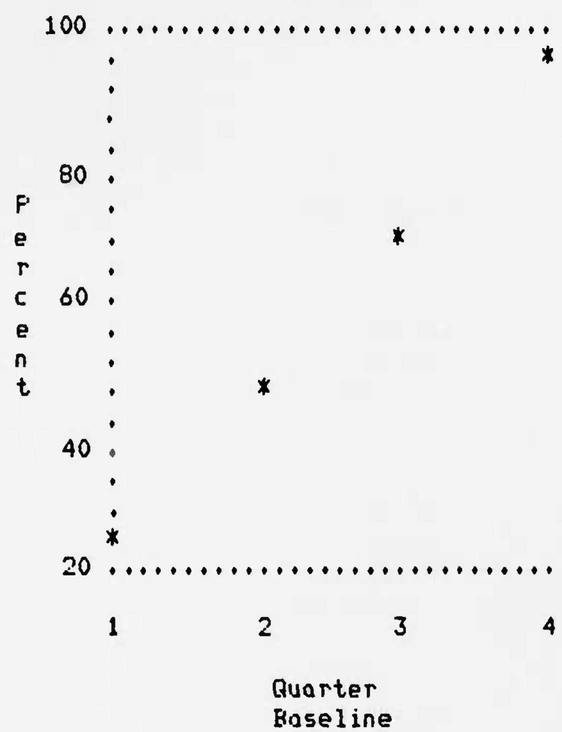
Camp Presly N. OBannon
(large)

Effectiveness Report No. 6

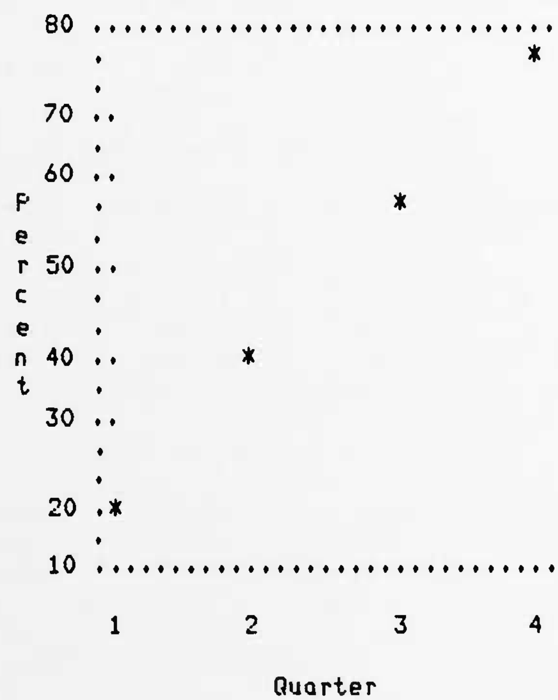
Element	First Qtr	Second Qtr	Third Qtr	Fourth Qtr
	Productivity Factors			
1	99.91	99.94	99.97	100.01
2	24.81	49.71	74.84	99.96
Sum	124.73	149.66	174.81	199.97
	Planning Factors			
3	18.97	37.99	56.95	75.91
4	9.97	10.19	10.32	10.57
5	74.33	74.59	74.90	75.21
Sum	103.27	122.78	142.18	161.69
	Reliability Factors			
6	99.89	99.98	99.94	100.07
7	24.97	49.97	74.92	99.97
Sum	124.86	149.95	174.85	200.04
	Initiation Factors			
8	.00	69.53	69.46	69.85
Sum	.00	69.53	69.46	69.85
Rating	103.35	131.60	153.19	173.58

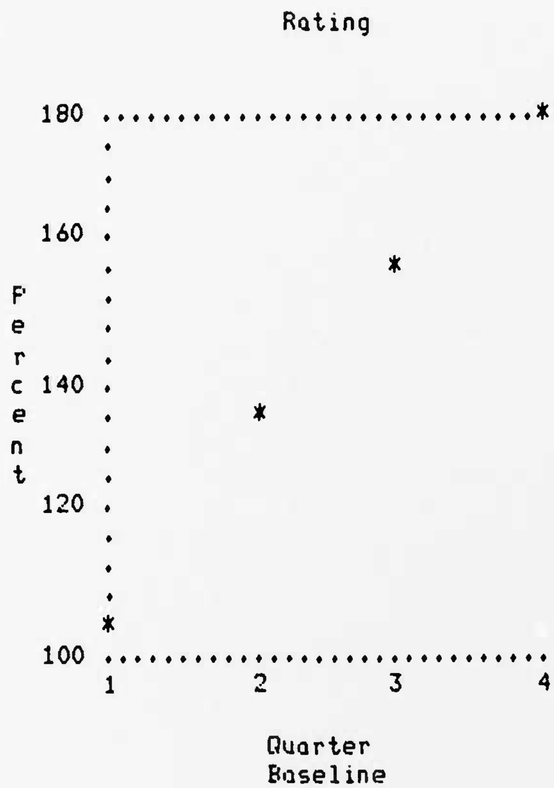
****

Element 3



Element 3




Rating
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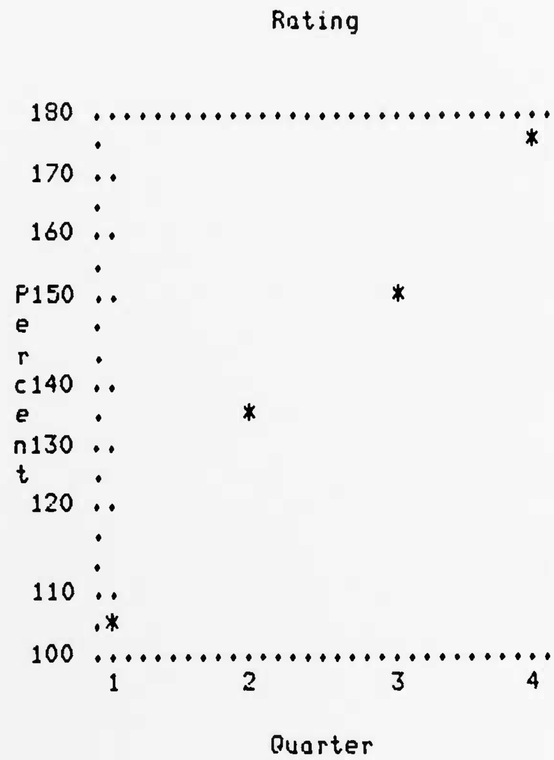
160
140
120
100
Percent
1
2
3
4
Quarter
Baseline


Rating
180
170
160
150
140
130
120
110
100
Percent
1
2
3
4
Quarter

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BIBLIOGRAPHY

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